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THE EARTH'S GRAVITY FIELD TO DEGREE AND ORDER 180 USING SEASAT ALTIMETER DATA, TERRESTRIAL GRAVITY DATA, AND OTHER DATA

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Research Foundation
Columbus, Ohio 432111

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The spherical harmonic expansion of the earth's gravitational field has been obtained to degree 180 by combining several sources of data. The first data set was an a priori set of potential coefficients to degree 36 based on a number of recent solutions including a substantial number of resonance terms. A second data set was a 1°x 1° anomaly field derived from the Seasat data set, while the third data set was an updated 1°x 1° terrestrial field. The last two fields were combined into one set containing 53761 1°x 1°

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values. The remaining values were computed from the a priori potential coefficients.

A rigorous combination solution was not carried out. Instead all anomalies were weighted in such a way that the normal equations were diagonal. The results of the adjustment were 64800 1°x 1° anomalies that were expanded into spherical harmonics using the optimum quadrature procedures developed by Colombo.

Accuracy estimates for each coefficient were obtained considering noise propagation and sampling error caused by the finite block size (~~1°x 1°~~)in which the anomalies are given. The percentage error of the solution reaches 100% near degree 120. The coefficients and their accuracy to degree 50 are listed in an appendix and the complete set is available on tape. The coefficients have been compared to other coefficient sets such as GEM10C and GRIM3.

Foreword

This report was prepared by Richard H. Rapp, Professor, Department of Geodetic Science and Surveying, The Ohio State University, Columbus, under Air Force Contract No. F19628-79-0027, The Ohio State University Research Foundation Project No. 711664. The contract covering this research is administered by the Air Force Geophysics Laboratory, Hanscom Air Force Base, Massachusetts, with Mr. George Hadgigeorge, Contract Monitor.

The author expresses his appreciation to Frank Lerch and James Marsh of the NASA Goddard Space Flight Center, Greenbelt, Md., who provided potential coefficient information for this study and who carried out the orbit tests with the adjusted fields of this paper. Other information was provided by Chris Reigber, Desmond King-Hele, Steve Klosko, J. Klokocnik, and Carl Wagner.

Introduction

The improvement of the earth's gravity field is a continuous task of geodesy. In the past years one procedure for this improvement has been through the combination of potential coefficient information derived through the analysis of satellite orbits with terrestrial gravity data (Kaula, 1966, Rapp, 1978, Lerch et als, 1979, Gaposchkin, 1980). Many of the solutions that were made were carried out with the gravity data defined in 5° equal area blocks. Such data was to be the dominant source of information for many potential coefficients above the degree of satellite sensitivity. Some concern was expressed in Rapp (1977a) about the information (or spectral) content within such blocks. In that study it was pointed out that information beyond the degree from the 180°/θ rule (θ is the block size in degrees) may be in the data. Since there was some evidence that the use of 5° anomaly blocks might not be the best size to use when higher degree solutions were being carried out, Rapp(1978) carried out a combination solution with 1°x 1° data. This solution used the potential coefficients and their accuracy from GEM9 (Lerch et al 1979) together with a 1°x 1° anomaly field created from the merger of terrestrial anomaly data, and anomaly data derived from the Geos-3 satellite altimeter. The combination solution was carried out with a priori potential coefficients taken to degree 12 only. This was necessary because of the large amount of computer time that would have been necessary for the rigorous adjustment of the satellite data and the 64800 1°x 1° anomaly set. One result of this adjustment was an adjusted set of 64800 1°x 1° anomalies that were then converted to a set of potential coefficients complete to degree 180 using the usual summation formulas and an algoritum described by Rizos (1979). This set of coefficients was described by Rapp (1979) and used for anomaly, geoid undulation, and deflection of the vertical computation as described by Tscherning and Forsberg (1981). The results in this latter paper (and comparisons with a 180x 180 potential coefficient by Lerch et als (1981)) indicated the value of a high degree and order potential coefficient solution.

One of the unsatisfactory aspects of the Rapp 1978 180 x 180 solution was the fact that satellite implied potential coefficients above degree 12 were neglected in the solution. This implied that the field would be inadequate for satellite orbit calculations. We then examined procedures that might be of help in incorporating the higher degree coefficients without significantly changing our computer requirements. The results are described in Rapp (1980) where we examined combination solutions made with the rigorous procedures used in Rapp (1978) with a similar

procedure using certain assumptions that led to a considerably simplified solution. Computations were carried out with both the rigorous and approximate approach to generate two sets of potential coefficients to degree 180. 180. One solution was that to 180 using the adjusted anomalies described in Rapp (1978) based on a combination with the GEM 9 coefficients. The two field were then compared to find the average percentage difference was 8.6%, the root mean square undulation difference was ±80 c, and the root mean square anomaly difference was 2 mgals. The percentage difference was 6.0% for degrees 2 through 12, increasing to 15.4% for 25 through 36 and then descreasing to about 8% for the higher degrees. Considering that the data noise percentage error would be high (>50%) we felt the difference between the rigorous solution and the approximate solution was small. This led us to believe it would be worth while to pursue an approximate combination solution using all the satellite derived potential coefficient information as well as the latest 1°x 1° data that might be available.

The results in Rapp (1980) also showed the problem of using 5° block averages in the combination solutions. To do this combination solutions, both 5° and 1° block data were used with the GEM 9 potential coefficients. We found that the differences between the coefficients of the two solutions increased significantly with degree. For example at degree 36 the percentage difference reached 74% although it was 21% at degree 21. These differences are caused by the differences in the spectral content of mean values of different sizes. This problem was examined by Colombo (1981) who carried out a theoretical and numerical analysis to predict the sampling error caused by the finite size of block being used. The results obtained by Colombo agreed quite well with the results obtained by Rapp (1980) in a purely numerical fashion.

As part of Colombo's studies it became apparent that there were several new techniques that might be used to obtain an optimal combination of satellite and gravity data. However some of these would require a significant programming effort. However, Colombo had indicated procedures that could be used in a very near optimal way to estimate potential coefficients to a high degree once a set of adjusted anomalies on a global basis were given.

We thus decided to carry out a new combination solution with new data, and using the approximate type of combination theory that would incorporate all available potential coefficient information. In the following sections we describe the theory used, the data, and the results.

The Combination Theory

Let $\bar{C}_{\ell m}$, $\bar{S}_{\ell m}$ be a set of fully normalized potential coefficients which occur in the following description of the earth's gravitational potential V :

$$V(r,\bar{\Phi},\lambda) = \frac{kM}{r}\left[1 + \sum_{\ell=2}^{\infty}\left(\frac{a}{r}\right)^{\ell}\sum_{m=0}^{\ell}(\bar{C}_{\ell m}\cos m\lambda + \bar{S}_{\ell m}\sin m\lambda)\cdot\right.$$
$$\left.\cdot\,\bar{P}_{\ell m}(\sin\bar{\Phi})\right] \tag{1}$$

where:

- $r,\bar{\Phi},\lambda$ are the geocentric coordinates of a point,
- a is a scale factor, usually taken as an equatorial radius,
- $\bar{P}_{\ell m}$ are the fully normalized potential coefficients.

If we are given a set of anomalies Δg , in a block size of $d\sigma$, we can relate the coefficients and anomalies with the following spherical approximation:

$$\left\{\begin{matrix}\bar{C}_{\ell m}\\ \bar{S}_{\ell m}\end{matrix}\right\}_{\Delta g} = \frac{1}{4\pi\gamma(\ell-1)}\iint_{\sigma}\Delta g\left\{\begin{matrix}\cos m\lambda\\ \sin m\lambda\end{matrix}\right\}\bar{P}_{\ell m}(\sin\bar{\Phi})d\sigma \tag{2}$$

where γ is an average value of gravity. If we let $N = \pi/\theta$ where θ is the mean anomaly block size. Colombo (1980, p.71) has expressed (2) in the following form:

$$\bar{C}^{\alpha}_{\ell m} = \frac{\mu_{\ell}}{\gamma(\ell-1)}\sum_{i=0}^{N-1}\sum_{j=0}^{2N-1}\int_{\sigma_{ij}}\bar{Y}^{\alpha}_{\ell m}(\bar{\Phi},\lambda)d\sigma\,\bar{\Delta g}_{ij} \tag{3}$$

where

$$\bar{C}^{\alpha}_{\ell m} = \begin{cases}\bar{C}_{\ell m} & \text{if } \alpha = 0\\ \bar{S}_{\ell m} & \text{if } \alpha = 1\end{cases}$$

$$\bar{Y}^{\alpha}_{\ell m} = \begin{cases}\bar{P}_{\ell m}(\sin\bar{\Phi})\cos m\lambda & \text{if } \alpha = 0\\ \bar{P}_{\ell m}(\sin\bar{\Phi})\sin m\lambda & \text{if } \alpha = 1\end{cases} \tag{4}$$

Equation (3) is referred to as a quadrature formula and μ_{ℓ} is called a de-smoothing factor. Colombo showed that the quadrature formula can give results for the estimation of the potential coefficients almost as good as a much more complicated optimal estimation procedure. As part of the use of the quadrature procedure Colombo recommended the following de-smoothing factors:

$$\mu_\ell = \frac{1}{4\pi\eta_\ell} \quad \text{where} \quad \mu_\ell = \begin{cases} \beta_\ell^2 & \text{if} \quad 0 \le \ell \le N/3 \\ \beta_\ell & \text{if} \quad N/3 < \ell \le N \\ 1 & \text{if} \quad \ell > N \end{cases} \tag{5}$$

β_ℓ is the Pellinen/Meissl smoothing or averaging operator. We have:

$$\beta_\ell = \cot \frac{\psi_0}{2} \quad \frac{P_{\ell 1}(\cos\psi_0)}{\ell(\ell+1)} \tag{6}$$

where ψ_0 is the radius of a circular cap having the same area as σ_{ij} (Rapp, 1977a). We also have:

$$\beta_\ell = \frac{1}{1-\cos\psi_0} \quad \frac{1}{2\ell+1} \left[P_{\ell-1}(\cos\psi_0) - P_{\ell+1}(\cos\psi_0)\right] \tag{7}$$

where P_ℓ is the Legendre polynomial of degree ℓ. A recursive procedure for finding β_ℓ is given by Sjoberg (1980).

The principle of the combination procedure used here was first discussed by Kaula (1966). The method is based on a comparison of the potential coefficients computed from (2) (or (3)) with those values derived from satellite data with an adjustment being performed, recognizing all the data is to be weighted, to obtain a consistent set of potential coefficients and anomalies.

We briefly describe this adjustment process as follows: A general function F is defined:

$$F = F(L_\ell{}^a, L_x{}^a) = 0 \tag{8}$$

where $L_\ell{}^a$ are the adjusted observations and $L_x{}^a$ are the adjusted parameters. A linearized observation equation is then formed:

$$B_\ell V_\ell + B_x V_x + W = 0 \tag{9}$$

where

$$B_\ell = \frac{\partial F}{\partial L_\ell}, \; B_x = \frac{\partial F}{\partial L_\ell}, \; W = F(L_\ell, L_x{}^\circ) \tag{10}$$

where L_ℓ are the actual observations and $L_x{}^\circ$ are the observed values of the quantities to be regarded as parameters (e.g. the potential coefficients) of the adjustment. If

P_ℓ and P_x are the weight matrices for the observations and parameters, respectively, we have for the correction to the observed parameters, V_x :

$$V_x = -(B_x' M^{-1} B_x + P_x)^{-1} B_x' M^{-1} W \tag{11}$$

with the corrections to the observed quantities (e.g. the gravity anomalies), V_ℓ "

$$V_\ell = P_\ell^{-1} B_\ell' M^{-1} (B_x V_x + W) \tag{12}$$

where

$$M = B_\ell P_\ell^{-1} B_\ell' \tag{13}$$

In our case we have:

$$F = L_x^\circ - L_x^c \tag{14}$$

where L_x° are the given estimates of the potential coefficients (e.g. the GEM 9 coefficients) and L_x^c are the coefficients computed from (2) or (3) with the observed set of gravity anomalies. In this case:

$$B_x = I \tag{15}$$

$$[B_\ell]_{pc} = \frac{-\mu_\ell}{\gamma(\ell-1)} \int_{\sigma_{ij}} \bar{Y}_{nm}(\bar{\phi},\lambda)d\sigma \tag{16}$$

The bracket around B_ℓ indicates that the expression on the right side of (16) is simply one element in the B_ℓ matrix. We note that (16) applies only for the partial derivations with respect to potential coefficients. We will also be interested in the zero and first degree terms of the spherical harmonic coefficients of the anomalies themselves. In this case (16) would be written.

$$[B_\ell]_{\Delta g} = -\mu_\ell \int_{\sigma_{ij}} \bar{Y}_{\ell m}(\bar{\phi},\lambda)d\sigma \tag{17}$$

Using (15) in (8) we have:

$$V_x = -((B_\ell P_\ell^{-1} B_\ell')^{-1} + P_x)^{-1} (B_\ell P_\ell^{-1} B_\ell')^{-1} W \qquad (18)$$

and equation (12) reduces to:

$$V_\ell = P_\ell^{-1} B_\ell' P_x V_x \qquad (19)$$

From equation (18) and (19) we can obtain the adjusted values of the potential coefficients and the adjusted anomalies:

$$L_a = L_{x^\circ} + V_x$$
$$L_\ell a = L_{\ell^\circ} + V_\ell \qquad (20)$$

Note that in these cases we have taken the observed values to be the approximate values to simplify the equation. Having a set of 64800 1°x 1° adjusted anomalies we can apply (2) or (3) to obtain a high degree spherical harmonic expression. The resultant coefficients should agree exactly with the adjusted potential coefficients, $L_x a$, with the higher degree terms representing the information in the 1°x 1° anomalies.

The above <u>adjustment</u> equations were those used in Rapp (1978). The computational effort in evaluating the matrix $B_\ell P_\ell^{-1} B_\ell'$ was sufficiently great that an adjustment to only degree 12 was made. In Rapp (1980) simplifications were made in an attempt to make a more complete solution. To carry out this simplification we assume that the observation weights for the anomalies are assigned as follows:

$$[P_\ell] = \frac{\cos\bar{\phi}}{m^2} \qquad (21)$$

where m is the accuracy of a 1°x 1° block assumed to the same for all blocks. P_ℓ is thus taken as a diagonal matrix. Assuming that P_x is also diagonal (18) becomes:

$$[V_x] = \frac{-[W]}{1 + A[P_x]} \qquad (22)$$

where

$$A = \frac{m^2 \Delta\phi\Delta\lambda\mu_\ell}{(\gamma(\ell-1))^2} \qquad (23)$$

Here $\Delta\phi$ and $\Delta\lambda$ are the latitude and longitude increments of the block. The obvious advantage of this technique is

that we are not required to form or invert the normal equations to obtain the adjusted coefficient or anomalies. On the other hand, to gain this advantage we must assume that all the 1°x 1° anomalies have the same accuracy and are implicitly weighted according to (21). Examination of (22) would show that we are really just computing a weighted average of the a priori coefficient and that implied by the anomaly data.

The A Priori Potential Coefficients and Their Accuracy

As a first step in arranging our data we will choose the starting potential coefficients. We first examine the GEM 9 potential coefficients and their estimated accuracy (Lerch et als 1979). These coefficients are based on satellite derived information only. The coefficients are complete to degree 20 with additional coefficients up to (30, 28). The accuracy of the geoid undulation, by degree for the GEM 9 coefficients is given in Table 1. The overall commission error from degrees 2 to 20 in the undulation is ±173 cm. The geoid undulation error by degree is plotted in Figure 1 on page 8. The cumulative error is shown in Figure 9 and the percentage error in Figure 11 on page 33. The percentage error is defined as

$$\%E_\ell = \frac{\sqrt{\sum_{m=0}^{\ell} (\Delta\bar{C}^2_{\ell m}+\Delta\bar{S}^2_{\ell m})}}{\sqrt{\sum_{m=0}^{\ell} (\bar{C}^2_{\ell m}+\bar{S}^2_{\ell m})}} \tag{24}$$

Since the GEM 9 potential coefficient set is now several years old we decided to estimate a second set of coefficients on the basis of potential coefficient solutions that now seem most current. In doing this we considered some recent solutions that were derived or tailored to specific satellites (such as Geos-3, Seasat, Lageos), and some solutions that derived just zonal harmonic coefficients, or resonance coefficients.

The only separate zonal coefficients that were considered were the odd zonal harmonics that were estimated by King-Hele et al. (1981b). The coefficients (and accuracies) used from this paper were from degree 3 to degree 19.

Coefficients determined by resonance analysis were also taken from several sources. Those coefficients for which we found information are as follows:

1) 12th order terms based on the analysis of four satellites (Reigber and Rummel, 1979). The recommended solution included

Figure 1

Geoid Undulation Accuracy, By Degree, From
Various Starting and Adjusted Potential Coefficient Sets

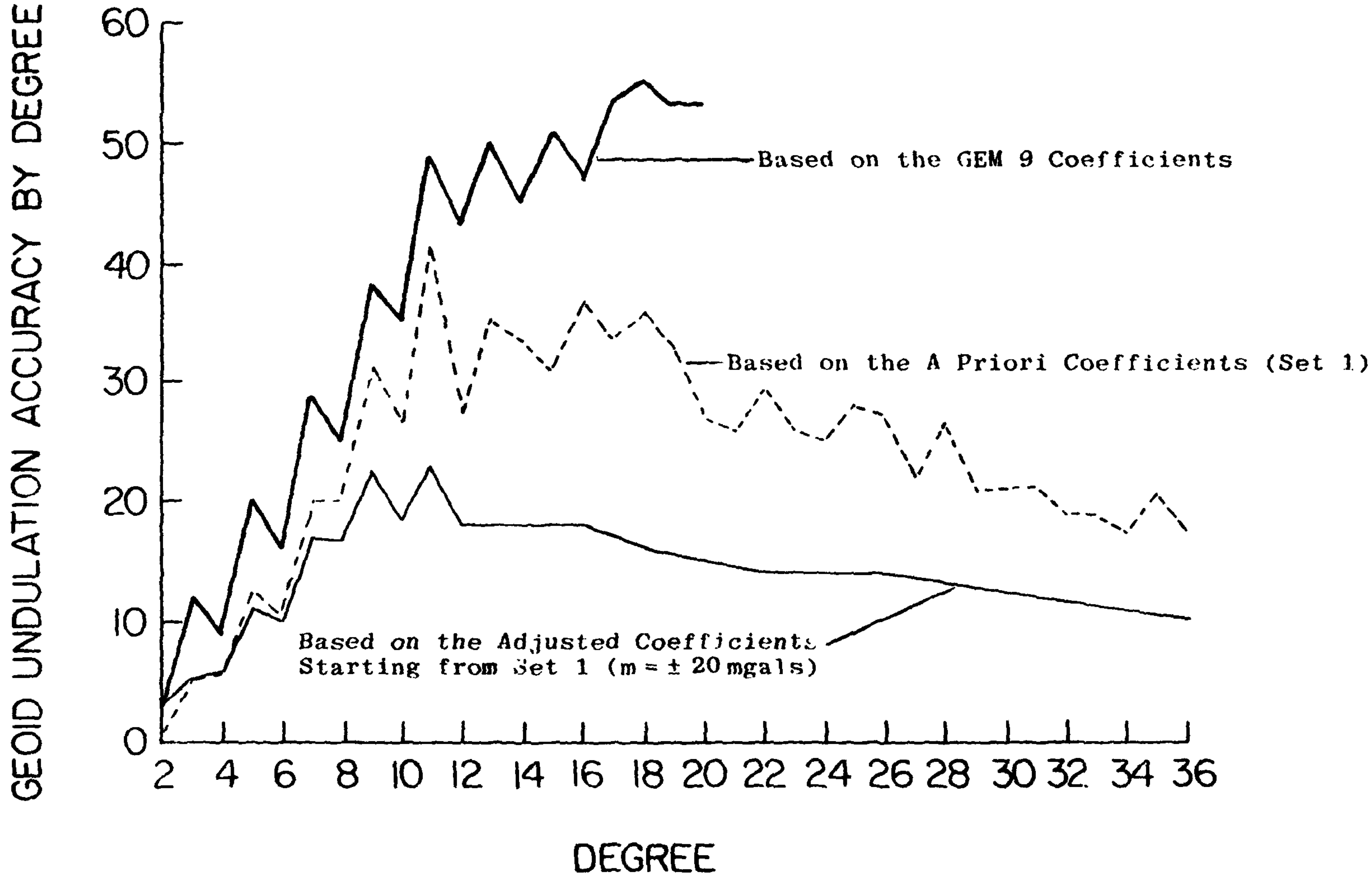


Table 1

Accuracy, By Degree, in the Geoid Undulation
Implied by Various Geopotential Models

ℓ	GEM 9	SET1	SET1 (adj)
2	3 cm	2 cm	2 cm
3	12	5	5
4	9	6	6
5	20	13	13
6	16	11	11
7	29	20	18
8	25	20	17
9	38	31	22
10	35	27	19
11	49	41	23
12	43	28	18
13	50	35	20
14	45	33	18
15	51	32	17
16	47	37	18
17	53	34	17
18	55	36	16
19	53	33	16
20	53	27	15
21		26	14
22		29	15
23		26	14
24		25	14
25		28	14
26		27	14
27		22	13
28		26	13
29		22	13
30		21	12
31		21	11
32		19	11
33		19	11
34		18	10
35		21	10
36		17	10

all 12 order coefficients and their accuracy from degree 12 to degree 30.

2) 13th order terms from Klosko and Wagner (1981). These terms were derived from the analyses of 13 satellites yielding 135 constraint equations. The recommended solution yielded 13th order coefficients and their accuracy from degree 13 through 30.

3) 14th order terms from Reigber and Balmino (1977), and King-Hele et als (1979). The Reigber and Balmino solution used data from 9 satellites to derive 27 condition equations which led to a recommended set of coefficients from degree 14 to degree 30. The King-Hele et al solution estimated the coefficients from degree 14 to degree 22. For purposes of merging with other data we adopted for use the King-Hele et al coefficients to degree 22, and the Reigber and Balmino coefficients from there to degree 30. The coefficients were also checked for consistency with the results of Kostelecky and Klokočnik (1979) who gave odd degree coefficients to degree 21.

4) 15th order terms were taken from King-Hele and Walker 1981b). In these computations 23 orbits were used to derive the potential coefficients and their accuracy from degree 15 through degree 35.

5) 30th order coefficients were taken from King-Hele (private communication. 1981) and from Kostelecky and Klokočnik (1979). The King-Hele (30, 30) coefficient was used with the even degree values to degree 42 from Kostelecky and Klokočnik.

We should note the care in which the use of the coefficients derived from the resonance analyses should be used. In essence a lumped coefficient is sensed, and the coefficient is separated by using satellites at different inclinations. If sufficient data is not used this separation will not be as good as one wants or needs. In addition high correlations may exist between the coefficients of a given solution. For our next steps, however, we will assume that accuracy estimates given by the authors are valid and that the coefficient estimates are independent.

We now consider more general solutions that may provide information towards our starting potential coefficient set. The ones considered were as follows:

1) the GEM 9 set which was previously described;
2) two solutions that were developed for better orbit estimation with the Seasat satellite (Lerch et als, 1981). The two solutions examined here were those known as PGS-S2 and PGS-S4. The PGS-S2 solution was based on the GEM 9 normal equations plus additional laser and S-band tracking of Seasat. The S4 solution added, to PGS-S2, the 5° anomaly data, Geos-3

and Seasat altimeter data. The S-2 field is complete to degree 30 with additional terms to degree 36, while S-4 is complete to degree 36. We will choose to work with the S2 solution because of concern with the use of 5° block data in S-4 although for tracking purposes (with Seasat) S-4 is the superior solution;

3) the PGS1331 field (Marsh, private communication 1981) is a set of potential coefficients tailored primarily to the orbit of the Starlette satellite. This was started from the GEM 9 normal equations with laser observations on Starlette added as well as other information including satellite altimeter data, and some laser observations on Lageous . The PGS1331 field is complete to 36,36 with additional terms to 48,43.

4) the PGS L-1 field (Lerch and Klosko, 1981) is a field built through the addition to the GEM 9 data set two years of laser observations on Lageos. This field is complete to degree 20 with additional terms to 30,29. The L-1 field is a significant improvement over the GEM 9 field at the lower ($\ell \leq 5$) degrees. A set of standard deviations for each coefficient was provided by Lerch (private communication, 1981).

5) the Rapp (1978) 180 x 180 field. This field was based on a combination solution with GEM 9, 1°x 1° terrestrial anomaly data, and 1°x 1° anomalies derived from the Geos-3 data available at that time.

6) the NWL1G solution described by Anderle (1979). This field was one tailored for Geos-3 orbits. It is complete to degree 13 with additional terms to 28,27. We did consider the recent potential field described by Gaposchkin (1980) but decided not to use it because essentially the same data was present in the previously described solutions.

Our task is to combine the potential coefficient information available in the above field to obtain a starting set of potential coefficients and their accuracy for the combination solutions. Ideally we might do this if we have the variance-covariance matrix for each solution. We do not have such information. And even then great concern would exist when combining tailored fields, and resonant coefficient information.

Before merging these coefficient sets we derived a set of 1°x 1° anomalies from the potential coefficient and compared them to a combined terrestrial/Geos-3 1°x 1° field. The purpose of doing this was to see if one or more field were significantly better than the other fields in comparisons with anomaly fields. Such comparisons in terms of the mean square anomaly difference are given, in Table 2, using 31210 1°x 1° "known" values having an estimated standard deviation smaller than 11 mgals. The computations were done for two cases of the maximum degree in the spherical harmonic expansion: 20, and 36 (except for PGS-S2). For the n = 20 case, the S-4 and 1331 fields seem to be most accurate. For the

case of n = 36, the 1331 field seems best. We should note that much of the differences seen is due to the fact that the 1°x 1° data has much high frequency information not present in the potential coefficient fields being tested. We conclude that there are small differences in the solutions, but they are perhaps not significant.

Table 2

Mean Square Difference Between 1°x 1° Anomalies Derived from a Potential Coefficient Field, and a Terrestrial/Geos-3 Data Set

	Mean Square Anomaly Difference (mgal^2)	
Field	NMAX=20	NMAX=36
GEM 9	365	-
PGS S-2	362	357*
PGS S-4	353	335
PGS1331	353	331
PGSL1	365	-
"SET1"	353	334

*to degree 30 only

We therefore choose an arbitrary merge procedure but one that should yield realistic estimates of the coefficients and their accuracy. Specifically we found a coefficient by forming a weighted average of the PGS S-2, PGS1331, PGSL1, and the miscellaneous coefficient. The weighting for the L1 and miscellaneous coefficients was done using the standard deviations for each coefficient. The standard deviations for the PGS1331 and the PGS S-2 fields were taken to be 0.9 that of the corresponding GEM 9 coefficient where it existed. If it did not exist we used the standard deviation of the miscellaneous coefficient. Since the 1331, S-2, and L-1 fields are also basically dependent on the GEM 9 data set, so then does our final result.

To compute the accuracy estimate of a particular coefficient we choose the smallest of the following values:
1) the standard deviation of the L1 solution;
2) the root mean square difference between the weighted mean value and all other corresponding values;
3) the standard deviation of the miscellaneous coefficient.

Again the above procedure is somewhat arbitrary. It does recognize that the formation of a weighted mean in the procedure used here may not, and probably does not, reduce the given error. And it does recognize the coefficients

that have good agreement between the various data sets considered. Our final set of coefficient formed by the above procedures will be called "SET1".

To have a preliminary check on the starting set of coefficients we calculated 1°x 1° anomalies from these coefficients and compared them to our 1°x 1° terrestrial data base. The mean square differences are shown in Table 2. We see that there is no significant change in the comparisons. The geoid undulation error, by degree, for this field is given in Table 1 and plotted in Figure 1. The overall commission error to degree 20 is ±120 cm as compared to ±173 cm for GEM 9. The commission error to degree 36 is ±152 cm. The anomaly degree variances have also been computed for the GEM 9 and ("SET1") coefficients and the results given in Table 3. We see no significant difference between the GEM 9 values and those implied by the "SET1" coefficients. The anomaly degree variances were computed as follows:

$$c_\ell = \gamma^2(\ell-1)^2 \sum_{m=0}^{\ell} (\bar{C}^2_{\ell m} + \bar{S}^2_{\ell m}) \tag{25}$$

In these equation the even degree zonal coefficients are given with respect to the reference coefficients implied by an ellipsoid whose flattening is 1/298.257222. A more accurate formulation of degree variance computations considering the Bjerhammer sphere is described by Jekeli (1978). A plot of the anomaly degree variances to degree 180 for the adjusted field is given in Figure 12 on page 34.

Our initial procedure was to carry out two combination solsolutions: one with the GEM9 potential coefficients and the other with the SET1 coefficients. Such adjustments were made with a preliminary 1°x 1° gravity field. Tests with the adjusted fields indicated that the GEM9 combination was poorer than the combination with the SET1 coefficients. Therefore, we decided to carry out only one combination solution and that would be with the "SET1" coefficients and their accuracy.

Table 3

Anomaly Degree Variances Implied By Various Potential Coefficient Solutions (mgal^2)

ℓ	GEM 9	"SET1"	Adj. with "SET1"
2	7.56	7.58	7.58
3	33.66	33.82	33.84
4	19.63	19.79	19.81
5	20.87	20.85	20.70
6	19.04	19.42	19.33
7	19.45	19.60	20.10
8	11.73	11.30	11.02
9	11.50	11.37	11.09
10	10.1	10.0	9.77
11	6.8	6.4	6.85
12	3.7	3.2	3.2
13	6.6	7.0	7.2
14	4.0	3.4	3.0
15	3.3	3.0	3.0
16	2.3	2.9	4.8
17	2.1	2.5	3.5
18	3.3	3.1	3.3
19	3.0	2.8	3.0
20	2.3	1.8	1.9
21		1.7	2.4
22		2.7	3.7
23		1.8	2.4
24		1.7	2.1
25		1.6	2.6
26		1.4	1.7
27		1.4	1.6
28		2.1	2.3
29		1.5	1.9
30		1.6	2.5
31		1.2	1.6
32		0.9	1.6
33		1.3	2.0
34		1.0	2.8
35		1.7	2.3
36		0.7	1.7

The A Priori Gravity Anomalies and Their Accuracy

The $1° \times 1°$ gravity anomalies to be used in the combination solution were based on a merging of a terrestrial data file and a set of anomalies derived from Seasat anomaly data.

The terrestrial data used was based on a preliminary update of a tape known as the October 1979 tape. This update used ten new data sources. Of special importance was the revision of approximately 400 anomalies in the southern part of Africa. The updated tape contained 42585 anomaly values. The location of these anomalies is shown in Figure 2.

The Seasat altimeter data was adjusted by Rowlands (private communication, 1981) to the point where the average crossover discrepency was ±28 cm. This data was then used to estimate 37905 $1° \times 1°$ anomalies and undulations some of which were on land and thus not reliable. The location of this data is shown in Figure 3.

The two anomaly sets were then merged together to form a set of 56761 anomalies which are shown in Figure 4. In this merger the following criteria were used:

1. For land blocks, use only the terrestrial data;
2. For oceanic blocks, use the terrestrial data if the standard deviation was ≤±5 mgals;
3. For an oceanic block, bordering land use terrestrial data when it exists;
4. Use terrestrial data (when it exists) in the Mediterranean Sea area due to possible tide problems in the Seasat analysis.
5. For all other blocks use the Seasat derived anomalies when it exists. The location where the Seasat anomalies (33905 values) are located is shown in Figure 5.

All anomalies were referred to the Geodetic Reference System 1980 (Moritz, 1980). Before any altimeter anomalies were used in the merger the atmospheric correction of -0.87 mglas was applied to the anomaly predicted using least squares collocation.

This new data set was compared to our earlier merger with Geos-3 data (Rapp, 1980). For the 52972 common values wer found a root mean square difference of ±7.5 mglas, with a maximum difference of 127 mgals. The root mean square standard deviation of all anomalies on the new merged tape is ±10.0 mgals.

In the application of equation (2) or (3) to the anomaly data a global estimate of 64800 $1° \times 1°$ anomalies is needed. The anomaly values remaining from the 56751 "known" values were set to the values implied by the "SET1" potential coefficients to degree 36. If one considers the standard deviation of these values to be ±30 mgals, the root mean square standard deviation of all 64800 $1° \times 1°$ anomalies is about ±15 mgals. For purposes of evaluating m in equation 21 we choose the average standard deviation to be ±20 mgals to allow for possible anomaly errors in the several largely unsurveyed areas.

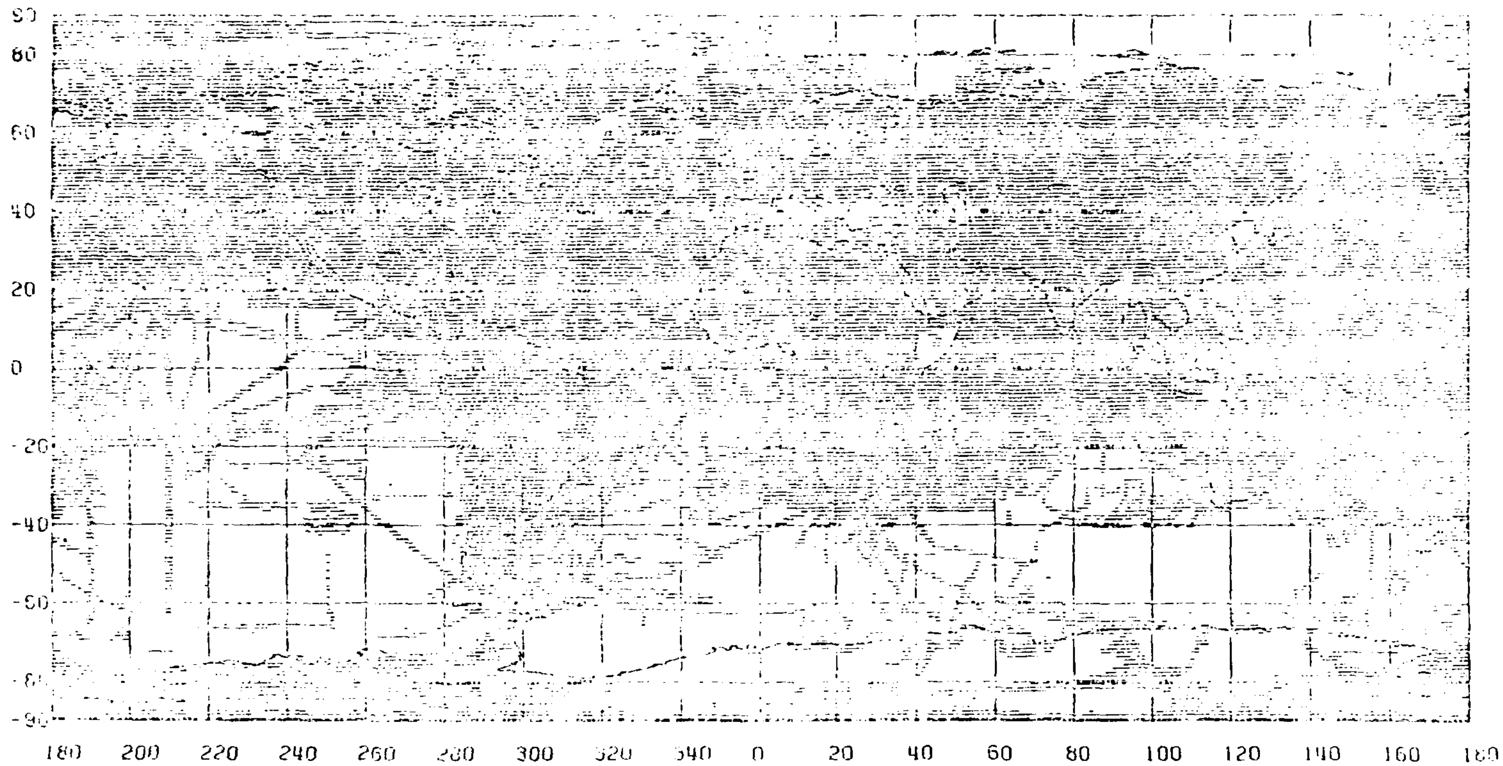


Figure 2: Location of 42585 1°x 1° Anomalies Based on Terrestrial Data

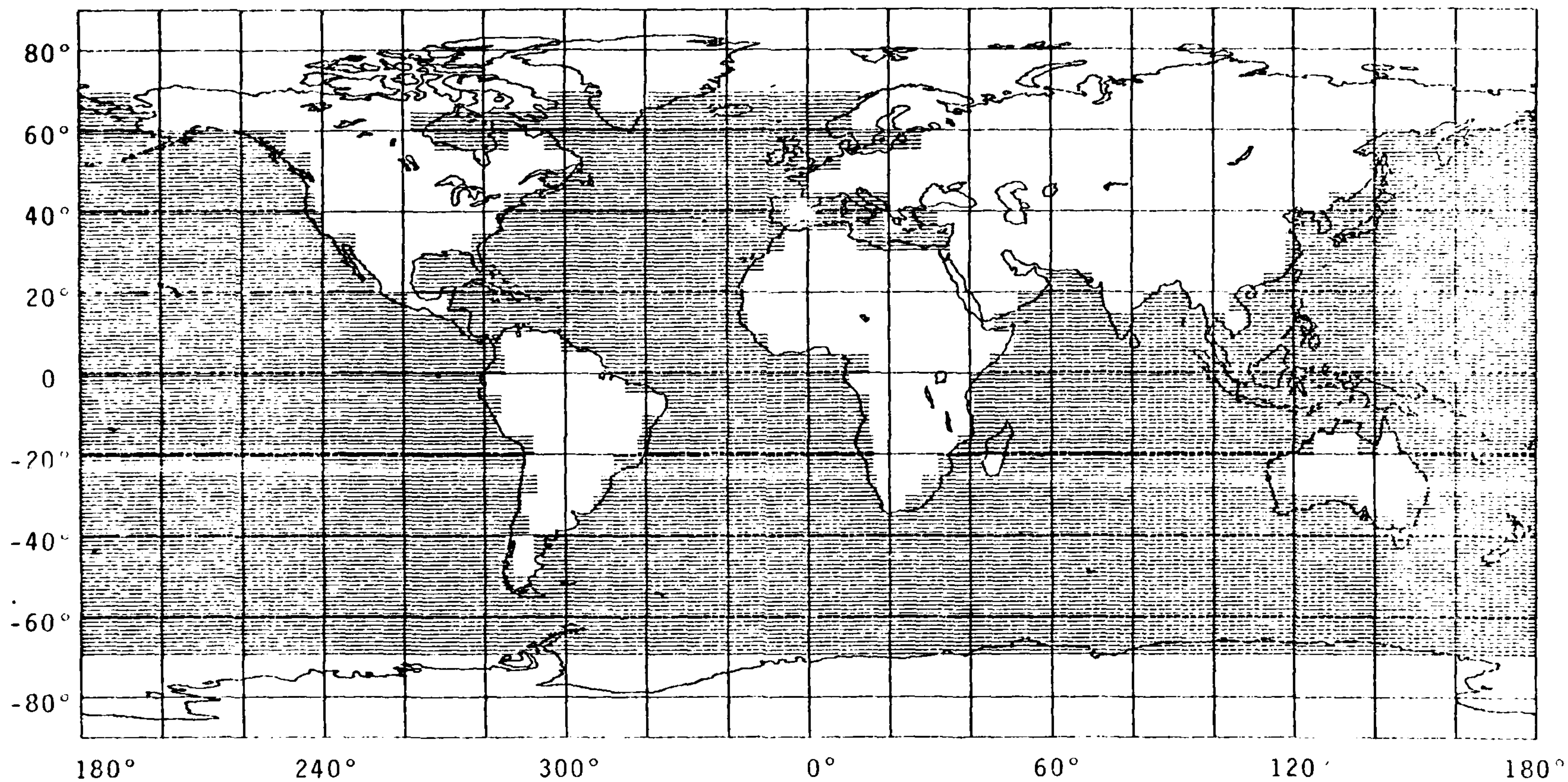


Figure 3: Location of 37905 1°x 1° Anomalies Derived From SEASAT Altimeter Data

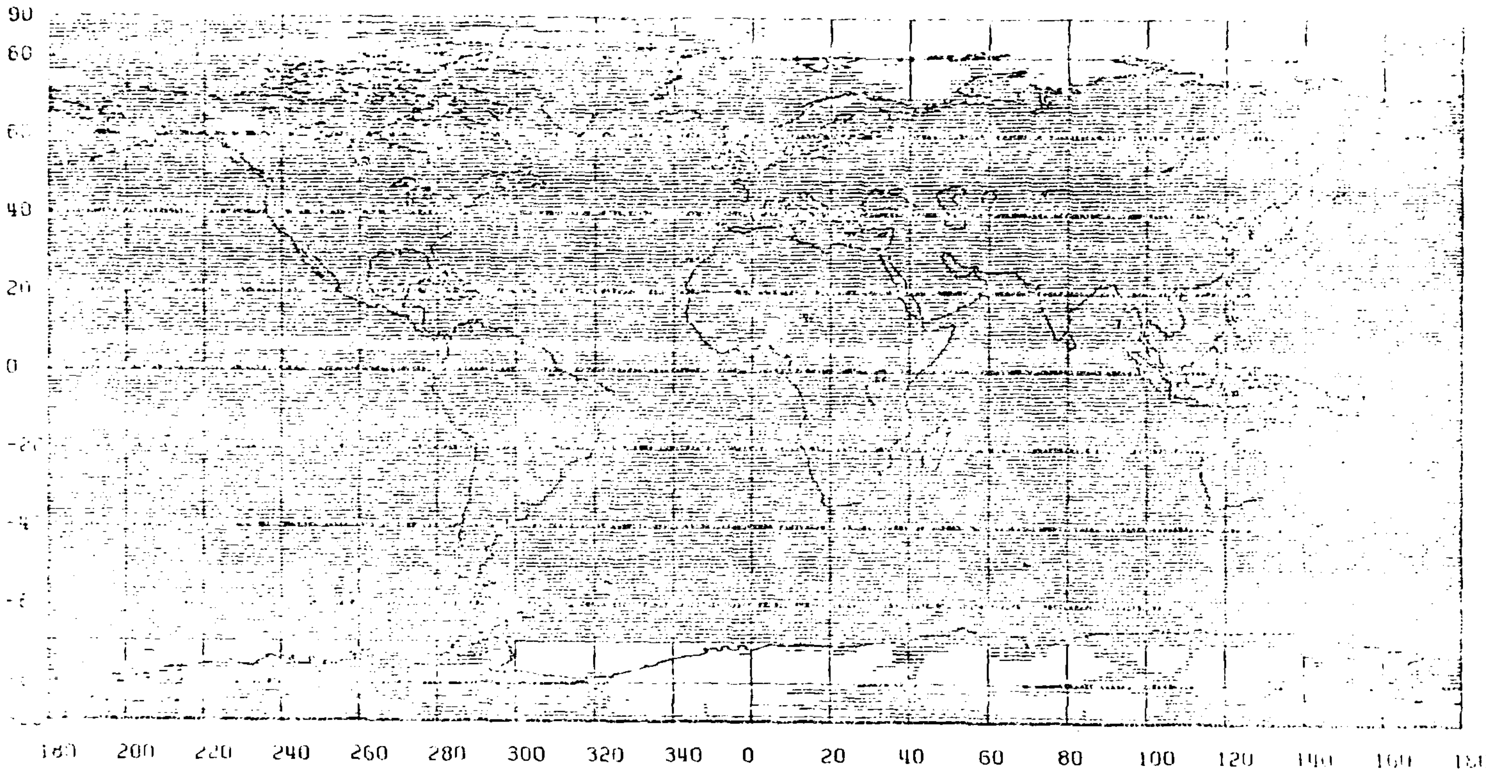


Figure 4: Location of 56761 1° x 1° Anomalies
As A Result of the Terrestrial/Seasat Merger

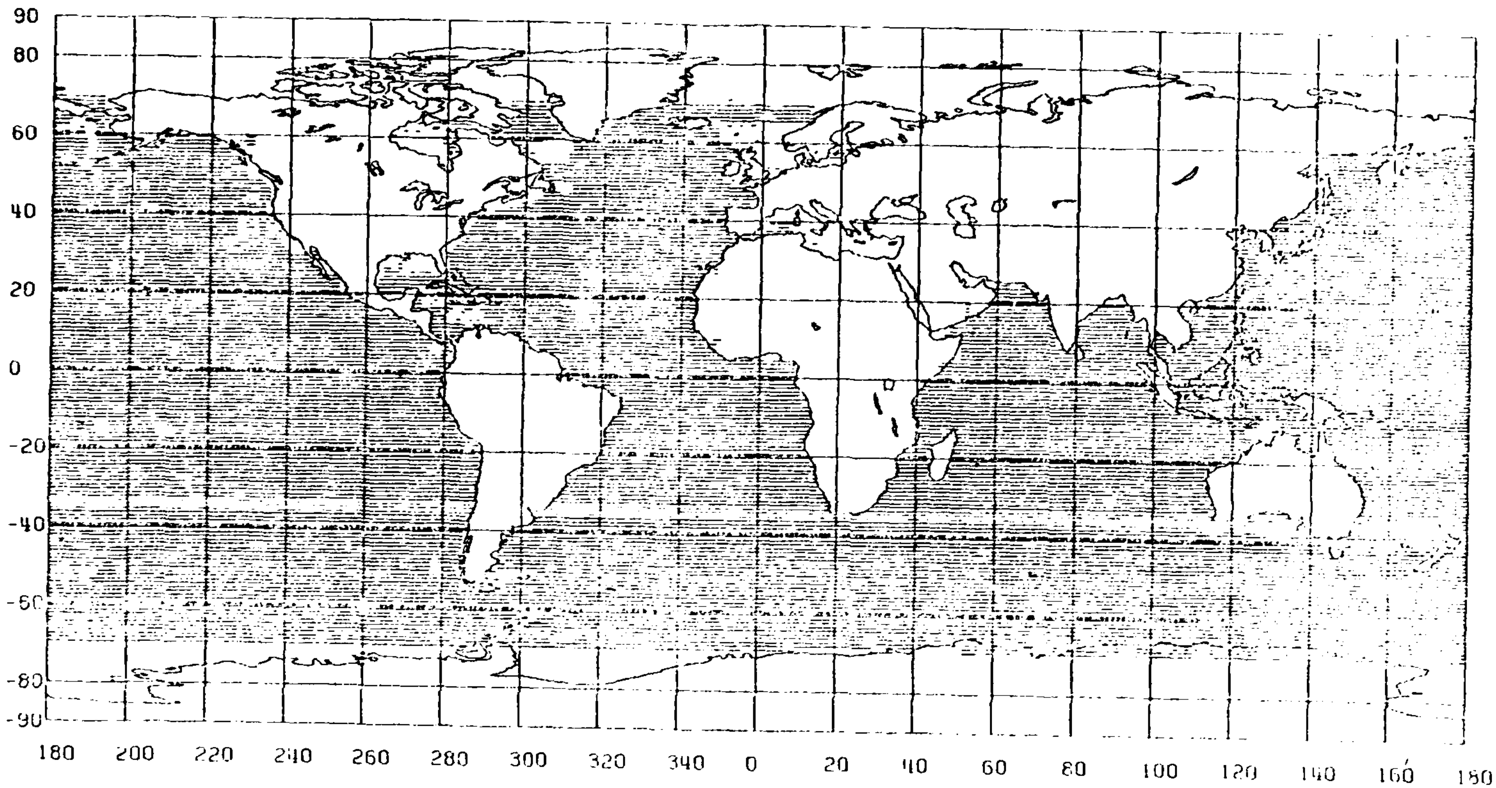


Figure 5: Location of 33905 1°x 1° Seasat Derived Values in the Merged Data Set

The Atmospheric Correction Terms for the Anomalies

The gravity anomalies described above have not been corrected for the effect of the mass of the atmosphere. In order to properly use equation (2) or (3) such corrections must be applied (Moritz, (1974), Rummel and Rapp (1976), Rapp (1977b)).

If Δg are the gravity anomalies referred to an ellipsoid where the total mass of the atmosphere has been condensed on its surface, the proper anomaly to use in (2) or (3) is:

$$\Delta g^{\circ} = \Delta g + \delta g_A \tag{26}$$

where δg_A is the atmospheric correction which has been tabulated, as a function of elevation, most recently in Moritz (1980a). (The sign convention used in (26) is opposite to that used in earlier papers but is consistent with that used in Moritz (1980b)). δg_A is 0.87 mgals for ocean blocks and land blocks whose elevation is zero. For blocks whose mean elevation is 5000 m. the correction is 0.47 mgals. Although this correction is small in terms of potential coefficient effects, it is easy to make and can remove a source of systematic error. Such corrections were made for our final data set.

The Ellipsoidal Correction Problem

Equations (2) or (3) represent spherical approximations to a more accurate solution considering the reference surface to be ellipsoidal. Tests described by Rapp (1977a) using correction terms from equations of Lelgemann (1973) showed that the corrections were small and could be neglected. Recently Pellinen (1981) has re-examined the Lelgemann solution and derived new corrected formulas that are in the same form as Lelgeman's. We can write from Pellinen (1981):

$$\begin{Bmatrix} \delta C_{\ell m} \\ \delta S_{\ell m} \end{Bmatrix} = e'^2 \left[p_{\ell m} \begin{Bmatrix} C_{\ell-2,m} \\ S_{\ell-2,m} \end{Bmatrix} + q_{\ell m} \begin{Bmatrix} C_{\ell m} \\ S_{\ell m} \end{Bmatrix} + r_{\ell m} \begin{Bmatrix} C_{\ell+2,m} \\ S_{\ell+2,m} \end{Bmatrix} \right] \tag{27}$$

where:

$$p_{\ell m} = - \frac{(3\ell^2-11\ell+14)(\ell-m-1)(\ell-m)}{2(\ell-1)(2\ell-3)(2\ell-1)}$$

$$q_{\ell m} = \frac{-2\ell^4+2\ell^2m^2-2\ell^3-4\ell m^2+9\ell^2+8m^2+9\ell-8}{2(\ell-1)(2\ell+3)(2\ell-1)} \tag{28}$$

$$r_{\ell m} = \frac{(\ell^2+5\ell+2)(\ell+m+2)(\ell+m+1)}{2(\ell-1)(2\ell+5)(2\ell+3)}$$

Here $\delta C_{\ell m}$, $\delta S_{\ell m}$ are the corrections to the coefficients that would be computed from (2) if geodetic latitudes were used in the computations. These correction terms were evaluated for the GEM 10B potential coefficients which are complete to degree 36. The maximum correction we found was 0.015×10^{-6} for $\bar{C}_{2,2}$. Other terms were considerably smaller. For example, at degree 22, the root mean square correction was $\pm 0.0009 \times 10^{-6}$. This value is consistent with the expected value predicted from $3 \times 10^{-8}/\ell$ given by Pellinen (1981) which was derived using the Kaula $10^{-5}/\ell^2$ decay rule for fully normalized potential coefficients.

We have decided not to use these correction terms. Instead we will use geocentric latitudes in all computations involving (2) or (3). This does not eliminate all concerns about the ellipsoidal and spherical reference surfaces. However, at low degrees where this effect will be greatest, the adjusted coefficients will be dominately determined by the satellite determined, a priori coefficients. At the higher degrees the effect of the spherical approximation is at least an order of magnitude below the uncertainty in our coefficients.

Results of the Combination Solution-General

The combination solution was made with SET1 a priori coefficients and the 64800 1°x 1° starting anomalies. The first result of the adjustment were the adjusted 1°x 1° anomalies and the adjusted potential coefficients corresponding to the a priori values. A number of comparisons and computations can be made for this adjusted data.

We consider first the accuracy of the geoid undulation, by degree, implied by the accuracy of the adjusted coefficients. The values were given in Table 1 on page 9 and are plotted in Figure 1 on page 8. The overall error from, degree 2 through 36 was ±152 cm for the starting coefficients and ±87 cm after the adjustment.

We have also compared the adjusted coefficients with the starting coefficients to see the magnitude and location (by degree) of the changes. These comparisons are in Table 4.

Table 4

Differences Between the A Priori Coefficients and the Adjusted Coefficients

		Solution with "SET1"	
ℓ	%	ΔN(cm)	$\delta\Delta g$(mgals)
2	0	0	.0
3	0	1	.0
4	0	2	.0
5	1	5	.0
6	1	8	.1
7	6	27	.2
8	9	26	.3
9	15	40	.5
10	14	32	.4
11	30	52	.8
12	19	20	0.3
13	24	36	0.7
14	52	45	0.9
15	35	28	0.6
16	42	40	0.9
17	42	32	0.8
18	39	27	0.7
19	47	29	0.8
20	55	26	0.8
21	47	24	0.7
22	41	25	0.8
23	47	22	0.7
24	47	19	0.7
25	53	23	0.9
26	57	19	0.8
27	59	19	0.8
28	49	18	0.7
29	76	24	1.0
30	63	22	1.0
31	81	23	1.0
32	65	17	0.8
33	62	18	0.9
34	61	20	1.0
35	61	18	0.9
36	79	19	1.0

In this table we have given the average percentage difference, the root mean square undulation and anomaly difference by degree. We see the percentage changes are greatest at the high degrees. This is primarily caused by a higher a priori standard deviation at such degrees.

The anomaly degree variances for the adjusted solutions are given in Table 3 on page 14. The most significant changes occur at the higher degrees with the new solution having somewhat larger values than the starting values.

The $1^\circ \times 1^\circ$ adjusted anomalies were compared to the adjusted anomalies of the earlier (Rapp, 1978) solution. The mean difference (new-old) was 0.5 mgals, the root mean square difference was ±11 mgals and the maximum difference of 215 mgals.

We also examined the magnitude of the residuals with respect to the standard deviations of the 64800 $1^\circ \times 1^\circ$ anomalies, although such standard deviations were not used in the solutions. The results are given in Table 5.

Table 5

Root Mean Square Residuals as a Function of the Initial Anomaly Standard Deviation

Range of Initial Anomaly Std. Dev. (mgals)	Adjustment with SET1 ($m = \pm 20$ mgals)
1-5	±3.0 mgals
6-10	2.7
11-15	4.5
16-20	4.9
21-25	5.4
26-30	3.5
31-35	5.0

We see from Table 5 a clear tendency for the residuals to be larger where the anomaly standard deviations are larger.

In Table 6 we are given the number of residuals having a given absolute magnitude value.

Table 6

Number of 1°x 1° Residuals
Having a Specified Range

Range (mgals)	Adjustment with "SET1"
0 to 2	30884
2 to 4	19855
4 to 6	8160
6 to 8	3363
8 to 10	1318
10 to 12	664
12 to 14	289
14 to 16	116
16 to 18	84

The location of the 3827 residuals whose magnitude is greater than 7 mgals is shown in Figure 6. The large residuals appear to be generally (but not always) correlated with the locations where the 1°x 1° anomalies have been geophysically predicted. These latter values (6413 on our latest terrestrial tape) are shown in Figure 7.

The adjusted anomalies from each solution were developed into spherical harmonic coefficients using subroutine HARMIN (Colombo, 1981) and the optimum quadrature weights given in equation (5). The expansions were made to degree 300 but results only to degree 180 will be discussed here. This is because the quadrature weights from (5) have a sharp discontinuity at degree 180. For example, at degree 180 (=180°/1°), the value of β_ℓ is 0.65 so that η_{180} is 0.65 but η_{181} is 1. An improvement is needed in the determination of the optimum quadrature weights beyond the Nyquist frequency.

The spectrum of the potential from the expansion of the adjusted anomalies is shown in Figure 8. Here the unitless spectrum is compute from:

$$V_\ell^2(\Delta U) = \sum_{m=0}^{\infty} (\bar{C}_{\ell m}^2 + \bar{S}_{\ell m}^2) \qquad (29)$$

An analysis of this spectrum and isostatic compensation

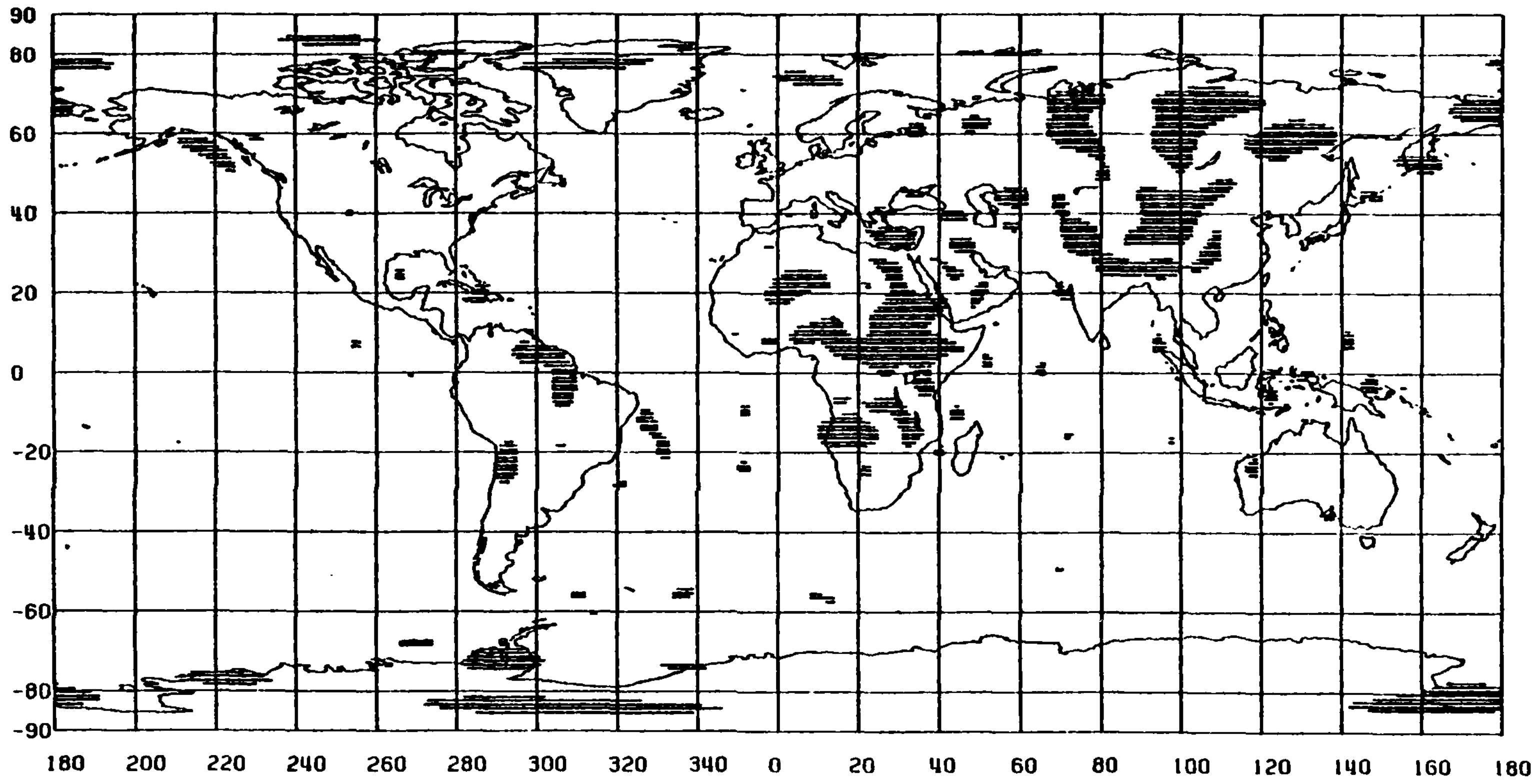


Figure 6: Location of 3827 Residuals Greater Than 7 mgals

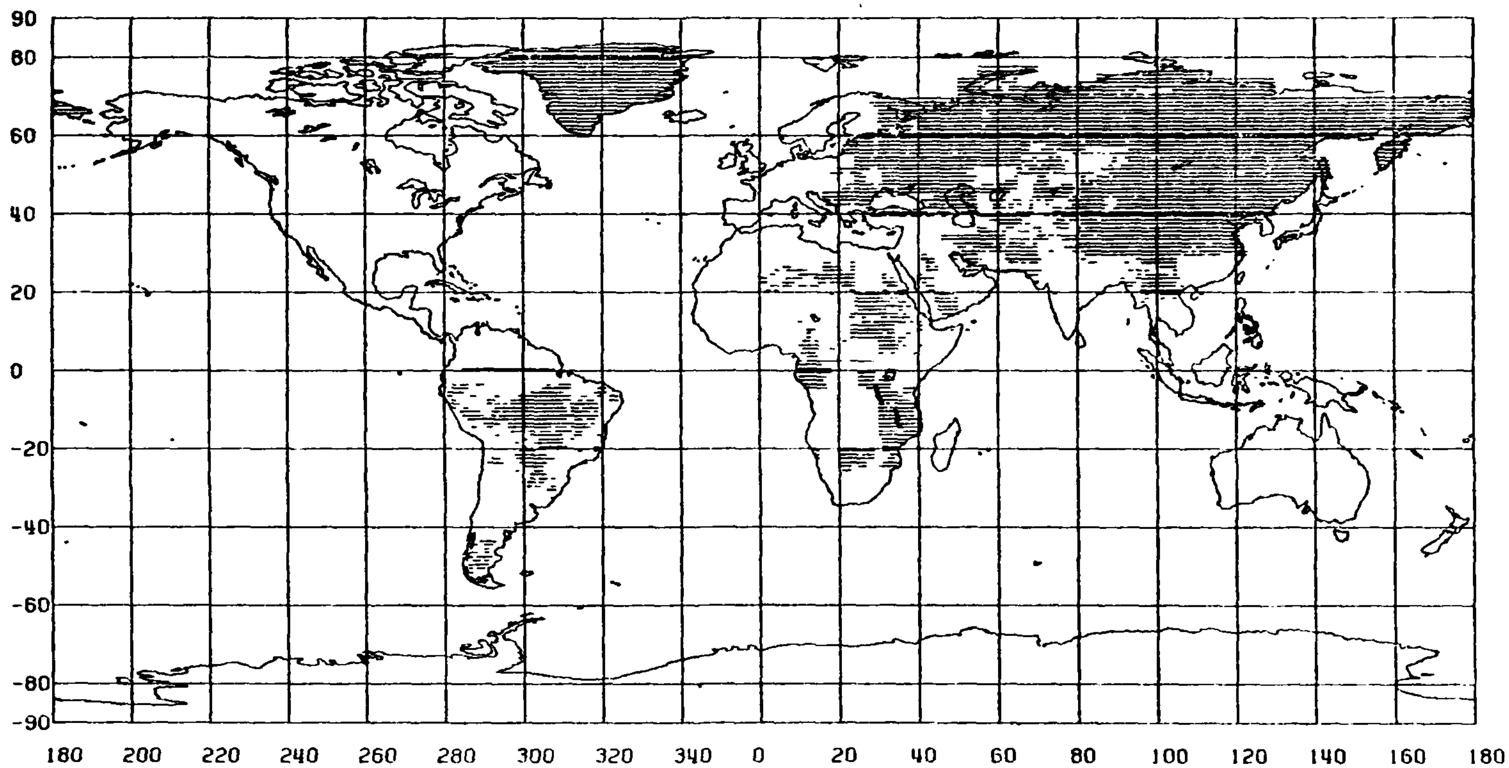
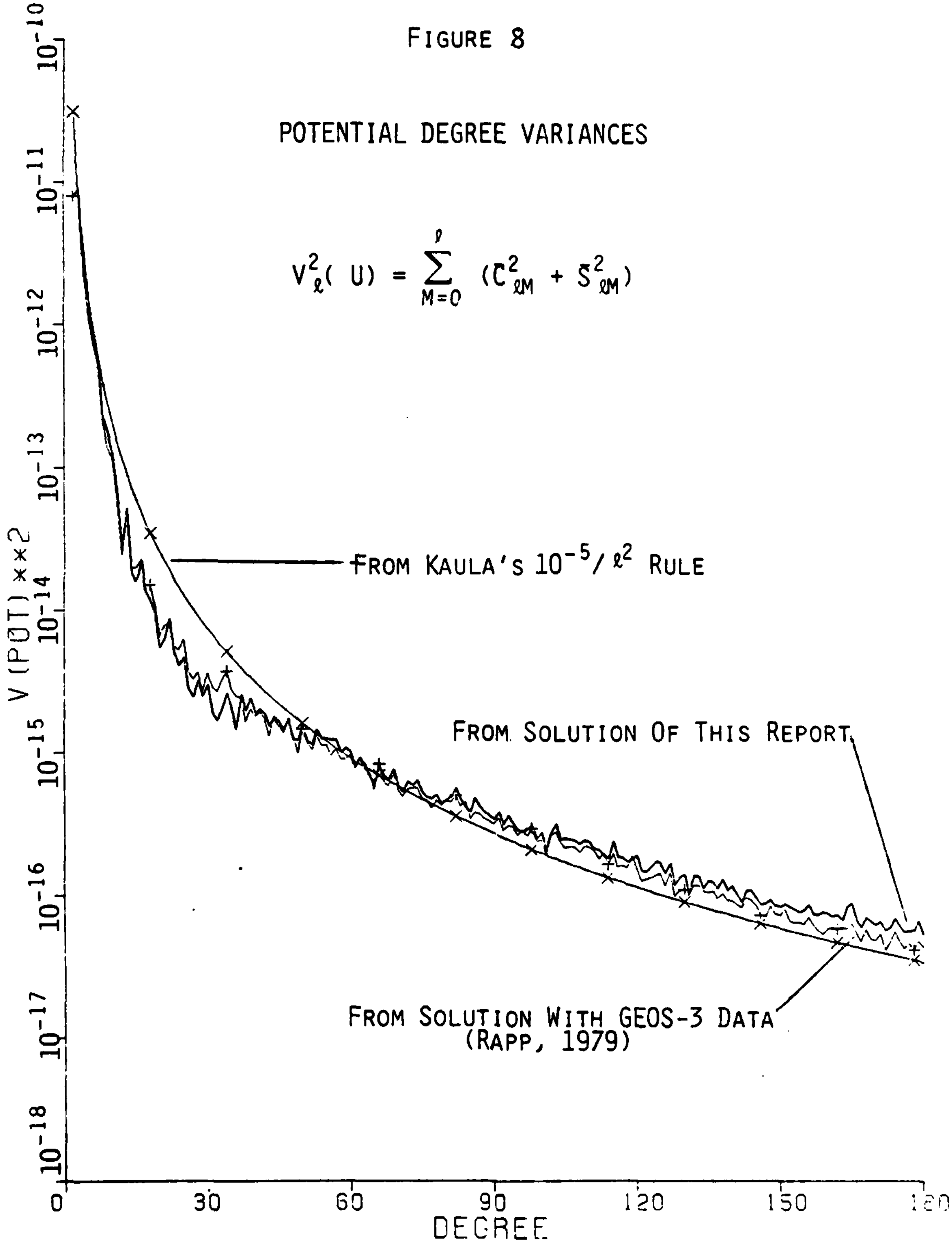


Figure 7: Location of 6413 1°x1° Anomalies Determined Through Geophysical Prediction

FIGURE 8

POTENTIAL DEGREE VARIANCES



is given in Rapp (1982). For comparison purposes we have also plotted the spectrum implied by the Kaula rule of thumb, and the spectrum implied by an earlier 180 model (Rapp, 1979).

Potential Coefficient Comparison

The potential coefficients of this combination solution have been compared to a number of other coefficient sets.. These results are given in Table 7.

Table 7

Potential Coefficient Comparisons with the Adjusted Coefficients of this Report

Solution	NMAX	RMS Coeff. Difference	Average Per Cent Diff.	RMS Und. Diff.	RMS Anomaly Difference
GEM9	20	$\pm 13.5 \times 10^{-9}$	34	±180 cm	± 3.6 mgals
GEM10B	36	$\pm 6.9 \times 10^{-9}$	47	±162 cm	± 5.0 mgals
GRIM3	36	$\pm 13.6 \times 10^{-9}$	60	±319 cm	± 6.5 mgals
Rapp 1979	180	$\pm 1.6 \times 10^{-9}$	42	±186 cm	± 9.1 mgals
GEM10C	180	$\pm 1.7 \times 10^{-9}$	81	±201 cm	±17.3 mgals

The percentage difference between the Rapp 1979 field and the newer field is 10% at degree 7, 23% at degree 10, increasing slowly to a 60% difference near degree 180.

The percentage difference between the GEM10C field (Lerch et als., 1981) and the new field is 7% at degree 7, 14% at degree 10, increasing slowly reaching 120% near degree 180. Of special interest is the very large anomaly difference between the two solutions of ±17 mgals. Much of this can be related to the combination techniques used and the basic 1°x 1° data sets which is somewhat different for each solution.

Adjusted Coefficient Accuracy

The standard deviation of the adjusted coefficients is part of the adjustment solution. When carrying out the high degree expansions it is necessary to assign approximate accuracy estimates to the coefficients that are not part of the adjustment. To do this we consider two error components: the first is due to the data noise, while the second is the sampling error (Colombo, 1981) due to the finite size of the 1°x 1° blocks.

The standard deviation of a fully normalized potential coefficient of degree ℓ based on anomaly data in a block of size θ (radians) can be written as (Rapp, 1972):

$$m(\bar{C},\bar{S})_\ell \Big|_{NOISE} = \frac{m(\Delta g)\,\theta}{2\gamma\sqrt{\ell-1}\,\sqrt{\pi}} \tag{30}$$

For our case $\theta^\circ = 1^\circ$ and $m(\Delta g)$ is 20 mgals.

The sampling error has been modeled by Jekeli based on computations of Colombo. This error can be expressed as Colombo, (1981, eq. 3.10):

$$m(\bar{C},\bar{S})_\ell \Big|_{SAMPLE} = \frac{\sigma_\ell}{100} \left([(-16.19570\,(\frac{\ell}{N}) + 30.34506\,(\frac{\ell}{N}) + 40.29588]\,(\frac{\ell}{N})^2\right) \tag{31}$$

where σ_ℓ is the root mean square coefficient of degree ℓ, and N is the Nyquist degree which is 180 for the $1^\circ \times 1^\circ$ data. Equation (31) was evaluated by first computing σ_ℓ based on the given coefficients. The two standard deviations were then quadratically added to yield a composite standard deviations for those coefficients not part of the actual adjustment. This merged set of coefficients were then used to compute several accuracy estimates of interest. Examples of the percentage error for the data noise and the sampling error are given in Table 8.

Table 8

Coefficient Percentage Error Due to Anomaly Data Noise ($\pm$20mgals) and the Sampling Error ($1^\circ \times 1^\circ$ Blocks)

Degree	Percent Error	
	Data Noise	Sampling Error
50	52%	4%
75	72	9
100	86	16
125	98	26
150	127	38
175	138	52

We see that the sampling error is considerably smaller than the data noise at the lower degrees but increases at the high degrees. In Figure 9 we have

plotted the geoid undulation error cummulativley for the GEM9 coefficient set by degree and cumulatively for the adjusted coefficients of this report.

In Figure 10 we have repeated the information of Figure 9 but for anomalies that would be calculated from the spherical harmonic expansions. Also shown is the cummulative anomaly error for the a priori coefficient. We next show in Figure 11 the percentage error several solutions. We see that the percentage error of the adjusted coefficients reaches 100% near degree 120. The increasing percentage error beyond this reflects the fact that the coefficients decay faster than the error in the coefficient determinations. Although the percentage errors are large at high degrees, the coefficient set as a whole contains significant information.

Anomaly Degree Variance Models

In a previous section (see Table 3, p. 14) we have discussed anomaly degree variances from various solutions to degree 36. It is now appropriate to consider these anomaly degree variances for the adjusted coefficients, of GEM10C and GRIM3 (Reigber, Balmino, Moynot, and Muller, 1981) which are complete to degree 36. These degree variances are plotted in Figure 12 along with that implied by Kaula's rule. The values from the GRIM3 model are higher after degree 20 than the values from GEM10C, and the new model. This is also reflected in the summation of the anomaly degree variances from degrees 2 to 36. This summation is as follows: GEM10C, 239 mgals; GRIM3, 265 mgals; new, 228 mgals. The anomaly degree variances for the GEM10C field are lower at the higher degrees than those implied by the new field. This may be due to the analysis technique and/or the data used.

Orbit Calculations with the New Models

The new potential coefficient set has been tested in a number of different satellite dependent calculations. This testing has been to see how badly the new model does in orbit work. This pessimism stems from the use of a coefficient set that has not been optimized for a certain satellite. We have tried to generate a general field that would be useful for both terrestrial applications and satellite applications.

The tests to be described were made at NASA's Goddard Space Flight Center by Frank Lerch and James Marsh. The tests are far from exhaustive.

The first test was made with Lageos in a 25 day arc. The computations were made with the complete 25 day arc,

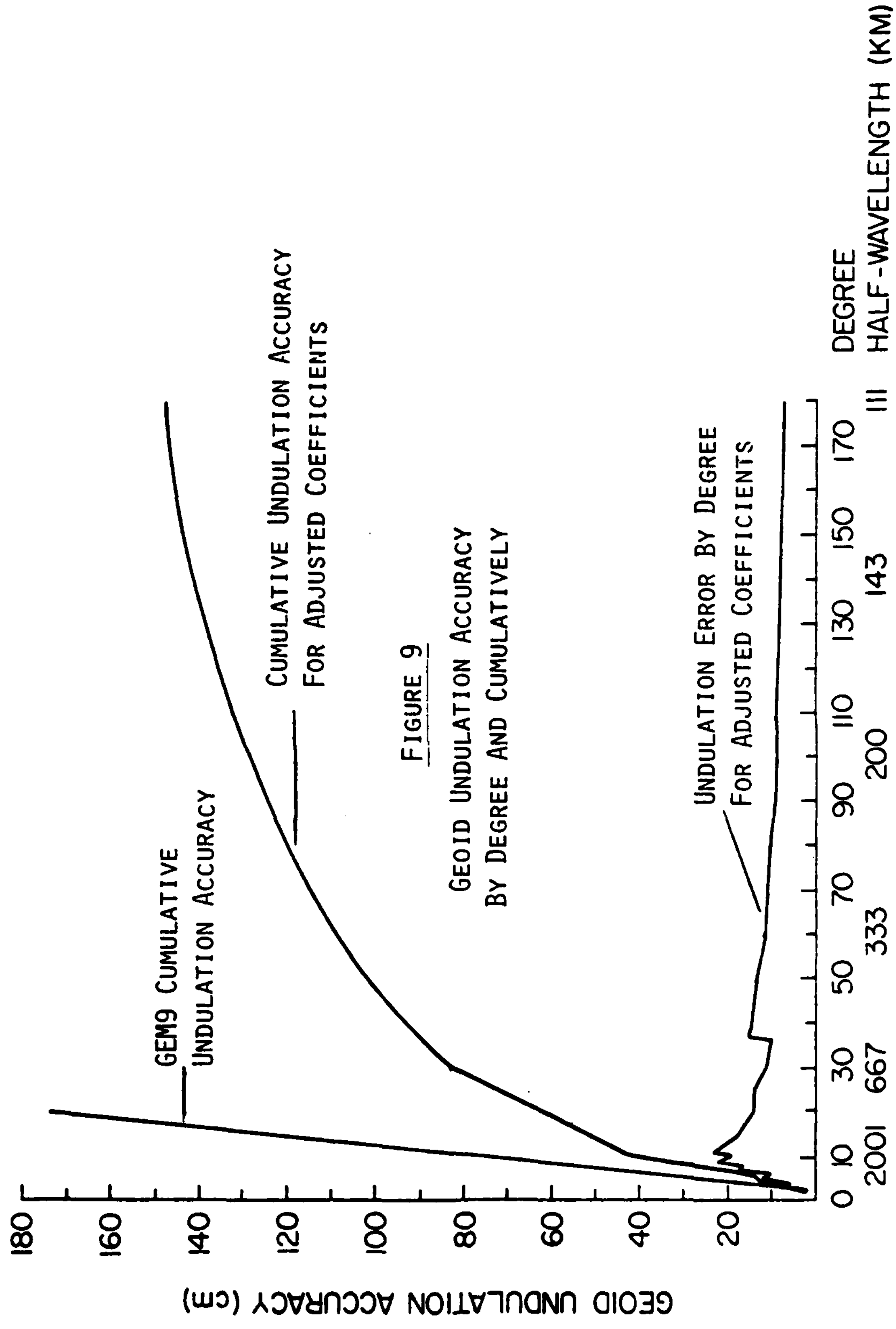


FIGURE 9

GEOID UNDULATION ACCURACY BY DEGREE AND CUMULATIVELY

FIGURE 10

GRAVITY ANOMALY ACCURACY BY DEGREE AND CUMULATIVELY

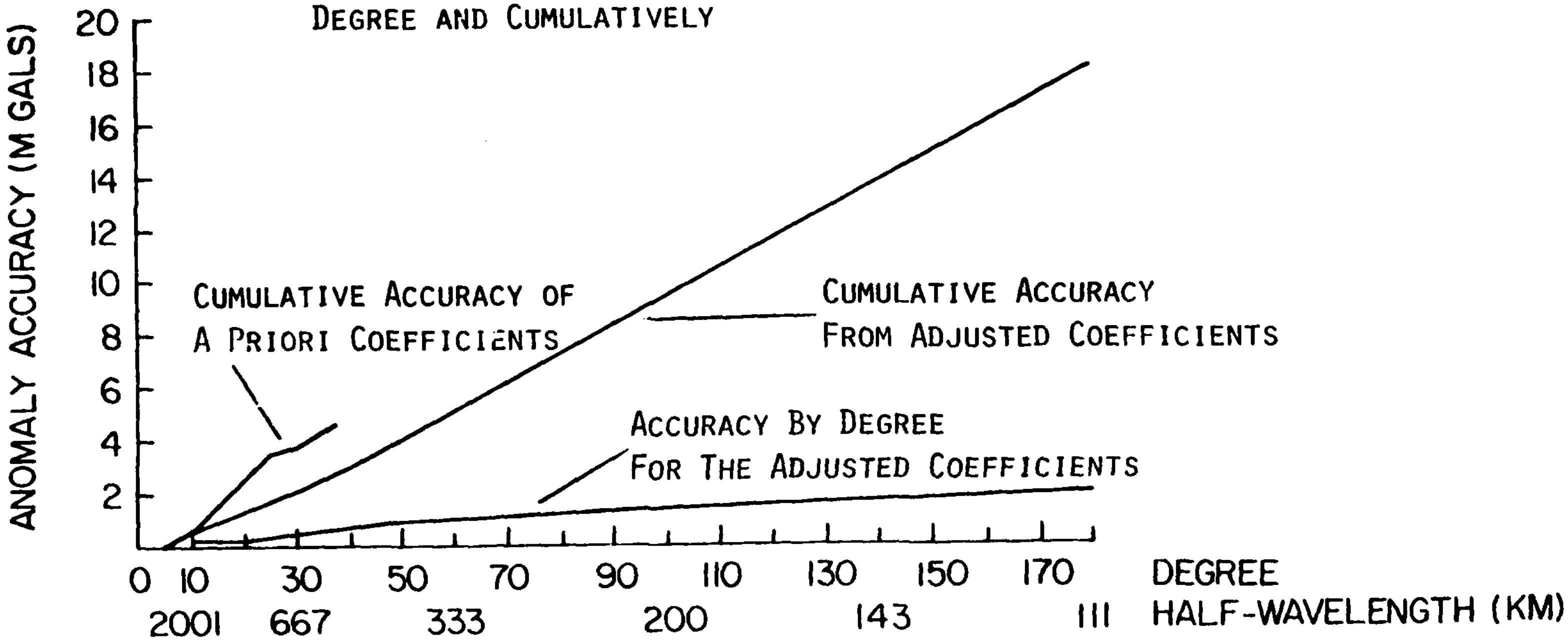


FIGURE 11

COEFFICIENT PERCENTAGE ERROR
AS A FUNCTION OF DEGREE

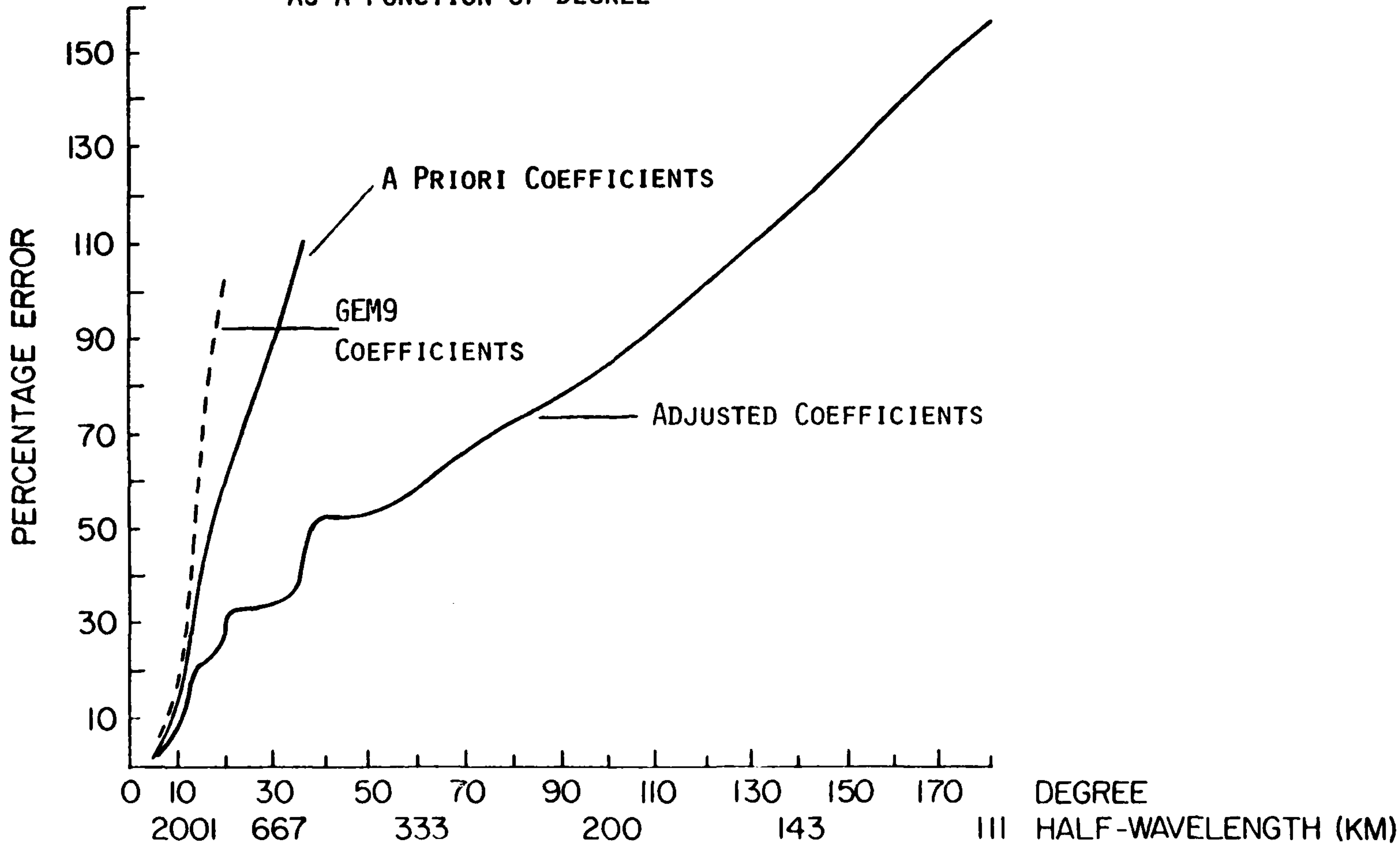
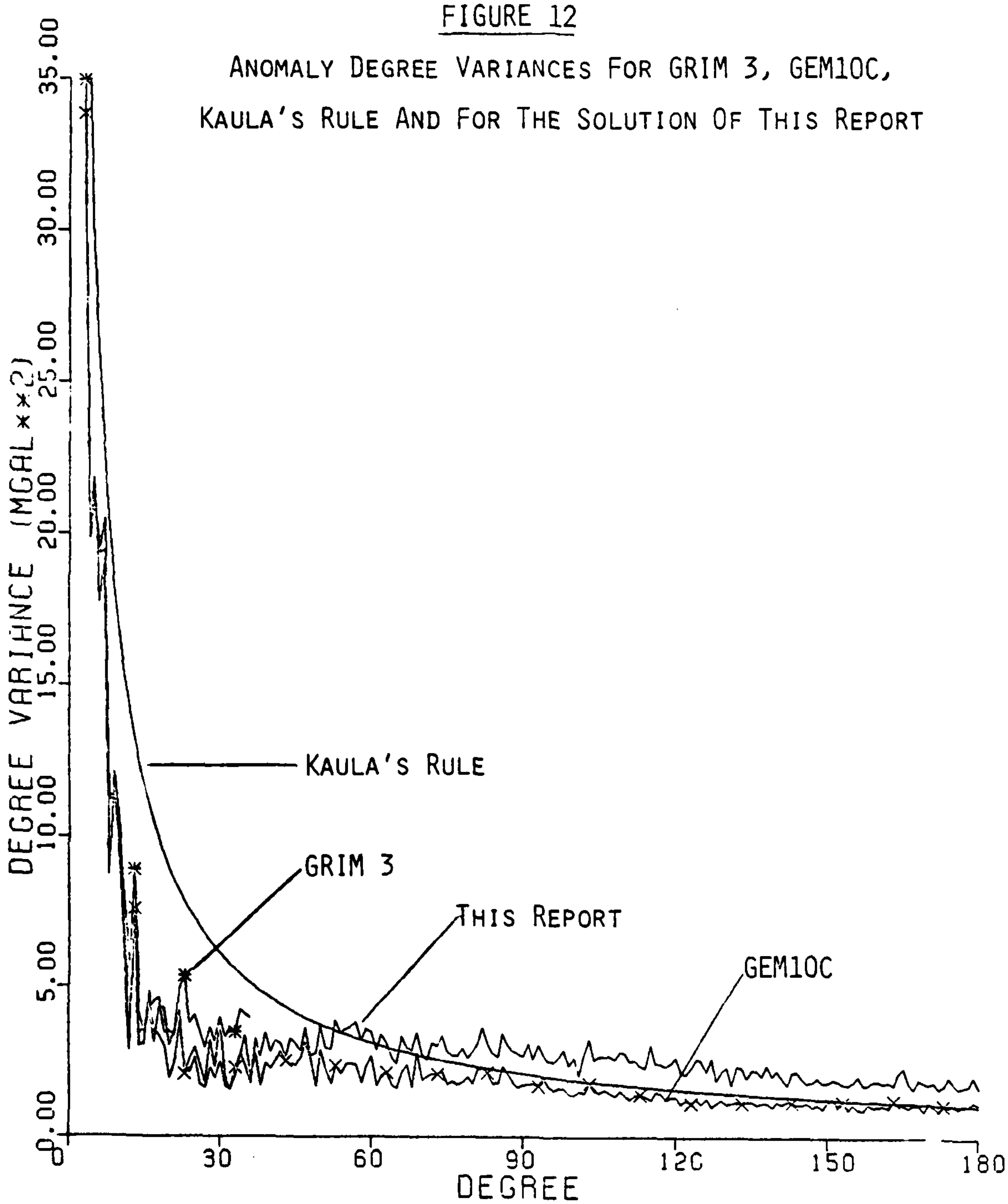


FIGURE 12

ANOMALY DEGREE VARIANCES FOR GRIM 3, GEM10C, KAULA'S RULE AND FOR THE SOLUTION OF THIS REPORT



and with 5 days deleted out of the middle of the arc. Then the root mean square orbit position difference and the root mean square residual for data within the 5 day segment were computed using several potential coefficient models. These results are given in Table 9.

Table 9

Computations Using Lageos with
Different Potential Coefficient Models

	GEM9	PGSL1	Rapp (B)
RMS Orbit Post. Diff.	±1.92 m	±0.81 m	±1.06 m
RMS Obs. Residual with 5 day gap	±22 cm	±19 cm	±20 cm

The next test involved the computation of 10 baselines involving 5 laser stations and two different sets of laser observations. The root mean square differences between the baselines for the different data sets was as follows: GEM9 (±17cm), GEM10B (±11cm), PGSL1 (±9cm,) Rapp (±9cm).

The solution of this paper performs nearly as well as the PGSL1 solution. This is due to the inclusion of the PGSL1 coefficient set into our solution with fairly large weights.

The next test was carried out using Starlette Laser data. Here approximately six 5 day arcs (with 2½ day overlap) were analyzed using the Rapp field to 36,36 only. The following are the average differences using the specified mode: PGS1331 (±0.65m), GEM10B (±2.1m), GEM9 (±2.6m), PGSL1 (±2.5m), and Rapp (±4.2m). Clearly the solution of this paper doesnot work as well as the other solutions.

Another test was made of the 11 order coefficients using the lumped 11 order coefficients given by Wagner and Lerch 1978). This test is of special interest as no specific 11 order resonance coefficients were incorporated in our a priori potential coefficient set. The root mean square difference was computed for 14 separate lumped coefficients as given by Wagner and Lerch and as computed from several coefficient sets. The results are given in Table 10.

Table 10

RMS Lumped Coefficient Comparison
(Wagner and Lerch (1978)) minus Computed Value)

Potential Coefficient Set	RMS Difference ($X10^9$)
GEM9 (to n=20)	±13.9
PGSL1 (to n=20)	±13.9
PGS1331 (to n=20)	±15.6
PGS1331 (to n=36)	±15.4
Rapp (to n=20)	±12.5
Rapp (to n=36)	±13.5
GRIM3 (to n=20)	±22.9
GRIM3 (to n=36)	±22.4

And our final comparison was with a set of 24 hour satellite accelerations determined by Wagner (1982, private communication). Using 8 different observed accelerations, Wagner tested the following coefficients: (2,2), (3,1), (3,3), (4,2), (4,4), (5,1), (5,3), (5,5), (6,2), (6,4), (6,6). The root mean square difference between the observed and the computed acceleration (in units of 10^{-8} rad/day) are: GEM9 (±5), GEM10B (±3.6), Rapp (±2.5), and PGSL1 (±1.0).

The point to be made here is that these tests indicate that this new solution for some cases is better than some existing solutions. Additional testing is needed to obtain a more complete picture of the performance of this new coefficient set in orbital work. One should not expect, this model to compete with models that have been specifically tailored to a given satellite.

Summary and Conclusions

We have generated new gravity field models based on improved theory and improved data. We have used more current satellite models, terrestrial data, and Seasat altimeter data. The data used included 1°x 1° data so that the sampling error could be reduced. We have incorporated in our error analyses the sampling error, as obtained by Colombo. This has enabled us to asses the accuracies of the various components of the model, such as undulations and anomalies.

The adjusted anomalies in our solutions were expanded into spherical harmonics to degree 180 and for some applications to degree 300. The expected error in the coefficients reaches almost 100% at the higher degrees (120).

The adjusted coefficients were used to compute anomalies which were compared to the input 1°x 1° data set for anomalies

whose standard deviation was ±7 mgals or smaller. The results for the adjusted coefficients and several other coefficient sets is given in Table 11.

Table 11

Mean Square Difference Between
Input 1°x1° Anomalies and
Anomalies Computed from the
Potential Coefficient Set

Field	NMAX = 20	NMAX = 36
GEM9	210 $mgal^2$	--
PSGL1	210 "	--
PGS1331	200	183
SET1	202	190
Adj.	182 $mgal^2$	180 $mgal^2$

We see a slightly better agreement for the adjusted field, but it is not substantial. The reason for this is the low relative weight assigned to the 1°x 1° anomaly data. The adjusted coefficients to degree 50 are given in the Appendix. The complete set to degree 180 (or to 300) is available on tape as are the adjusted 1°x 1° anomalies.

At the conclusion of this study it is clear that several things could have been done differently. Some items:

1. Sea surface topography corrections should be made to the altimeter data to reduce long wavelength errors in the derived anomaly field.

2. Better terrestrial data is needed. This is especially true in areas where geophysical anomalies now exist.

3. The optimization procedures for the combination of these data types should be implemented to assume a more rigorous combination solution.

References

Anderle, R., The Ocean Geoid Deduced from Geos-3 Satellite Radar Altimetry Data, in The Use of Artificial Satellite for Geodesy and Geodynamics, Volume II, ed. by Veis and Livieratos, National Technical University, Athens, Greece, 1979.

Colombo, O., Numerical Methods for Harmonic Analysis on the Sphere, Reports of the Dept. of Geodetic Science, No. 310, The Ohio State University, Columbus, Ohio 43210, 145 pp, 1981.

Gaposchkin, E.M., Global Gravity Field to Degree and Order 30 From Geos-3 Satellite Altimetry and Other Data, J. Geophys. Res., 85, B12, 7221-7234, 1980.

Jekeli, C. An Investigation of Two Models for the Degree Variances of Global Covariance Functions, Dept. of Geodetic Science Report No. 275, 72p. 1978.

Kahn, W.D., S. Klosko, W. Wells, Mean Gravity Anomalies from a Combination of Apollo/ATS-6 and Geos-3/ATS-6 SST Tracking Campaigns, NASA Technical Memorandum 82120, Goddard Space Flight Center, Greenbelt, MD 20771, 1981.

Kaula, W., Tests and Combination of Satellite Determinations of the Gravity Field with Gravimetry, J. Geophys. Res., 71, 5303-5314, 1966.

King-Hele D. G., D.M.C. Walker, R.H. Gooding, Evolution of 14th Order Harmonics in the Geopotential, in the Use of Artificial Satellite for Geodesy and Geodynamics, Volume II, ed. by Veis and Livieratos, National Technical University, Athens, Greece, 1979.

King-Hele, D.G., and D.M.C. Walker, Evolution of 15th Order Harmonics in the Geopotential from Analyses of Resonant Orbits, Royal Aircraft Establishment, TR81006, Farnborough, Hants, U.K., 1981b.

King-Hele, D.G., C.J. Brookes, and G.E. Cook, Odd Zonal Harmonics in the Geopotential from Analyses of 28 Satellite Orbits, Geophys, J. R. astr. Soc., 64, 3-30, 1981a.

Klosko, S.M., and C.A. Wagner, Spherical Harmonic Representation of the Gravity Field from Dynamic Satellite Data, Paper presented at the XVII IUGG meeting Canberra, 1979, revised 1981.

Kostelecky, J. and J. Klokočnik, 14th and 30th Order Harmonics from Resonant Inclination Variations, paper presented at the XVII IUGG meeting, Canberra, 1979.

Lelgemann, D., Spherical Approximation and the Combination of Gravimetric and Satellite Data, Bullettino Di Geodesia E Scienze Affini, XXXII, M. 4, 1973.

Lerch F.J., B. Putney, C. Wagner and S. Klosko, Goddard Earth Models for Oceanographic Applications, Marine Geodesy, Vol. 5, No. 2, 1981.

Lerch, F.S., et als., Gravity Model Improvement with Geos-3 (GEM 9 and 10), J. Geophys. Res., 84, B8, 3897-3916, 1979.

Lerch, F.J., J.G. Marsh, S.M. Klosko, and R.G. Williamson, Gravity Model Improvement for Seasat, J. Geophys. Res., in press, 1981.

Lerch, F.J., and S.M. Klosko, Gravity Model Improvement Using Laser Data: Progress Report, paper presented at: First Crustal Dynamics Working Group Meeting, Goddard Space Flight Center, Greenbelt, MD 20771, Sept. 1981.

Moritz, H., Precise Gravimetric Geodesy, Department of Geodetic Science Report No. 219, The Ohio State University, Columbus, 1974.

Moritz, H., Geodetic Reference System 1980, in the Geodesist's Handbook 1980, Bulletin Geodesique, 54, 3, 395-405, 1980a.

Moritz, H., Advanced Physical Geodesy, Abacus Press, Tunbridge Wells, Kent, U.K., 1980b.

Pellinen, L.P., Effects of the Earth Ellipticity on Solving Geodetic Boundary Value Problems, paper presented to VIII International Hotine Symposium on Mathematical Geodesy, Como, Italy, Sept. 1981.

Rapp, R.H., Accuracy of Potential Coefficients Obtained from Present and Future Gravity Data, in the Use of Artificial Satellites for Geodesy, Geophysical Monograph 15, American Geophysical Union, Washington, D.C. 1972.

Rapp, R.H., The Relationship Between Mean Anomaly Block Sizes and Spherical Harmonic Representations, J. Geophys., Res., 82, 5360-5364, 1977a.

Rapp, R.H., Determination of Potential Coefficients to Degree 52 from 5° Mean Gravity Anomalies, Bulletin Geodesique, 51, 301-323, 1977b.

Rapp, R.H., A Global 1°x 1° Anomaly Field Combining Satellite, Geos-3 Altimeter and Terrestrial Anomaly Data, Dept. of Geodetic Science, Report No. 278, 17p., 1978.

Rapp, R.H., A Review of Anomaly and Undulation Determinations from Geos-3 Altimeter Data, presented at the 1979 Spring Meeting, American Geophysical Union, Washington, D.C., May, 1979.

Rapp, R.H., Comparison of Potential Coefficient Determinations with 5° and 1° Anomalies, Dept. of Geodetic Science Report No. 300, 13pp., 1980.

Rapp, R.H., High Degree Spectrums of the Earth's Potential, Topography, and It's Isostatic Compensation, Bulletin Geodesique, 1982.

Reigber, C., and G. Balmino, 14th-Order Harmonics from Analyses of Mean Longitude Variations of Resonant Satellites, Lehrstul für Astronomische und Physikalische Geodäsie, Technische Universitat München, Mitteilung Nr. 132, Munchen 1977.

Reigber, C. and R. Rummel, 12th Order Harmonics from Resonant Perturbations of Satellies Using Non-Homogeneous Weight Functions, in The Use of Artificial Satellites for Geodesy and Geodynamics, Volume II, ed. by Veis and Livieratos, National Technical University, Athens, Greece, 1979.

Reigber, C., G. Balmino, B. Moynot, H. Müler, The GRIM3 Earth Model Parameters, Internal Report, DGFI/GRGS, Oct. 1981.

Rizos, C., An Efficient Computer Technique for the Evolution of Gepotential from Spherical Harmonic Models, Australian Journal of Geodesy, Photogrammetry and Surveying, No. 31, 161-170, 1979.

Rummel, R., and R.H. Rapp, The Influence of the Atmosphere on Geoid and Potential Coefficient Determinaiions From Gravity Data, J. Geophys. Res., 81, 32, 5639-5642, 1976.

Sjoberg, L., A Recurrence Relation for the β_n-function, Bulletin Geodesique, 54, 69-72, 1980.

Tscherning, C.C., Assessment of Two 180 x 180 Degree and Order Gravity Field Models in Scandinavia and In The Norwegian Greenland Seas, Abstract EOS, Vol. 62, p.262, 1981.

Tscherning, C.C., and René Forsberg, Geoid-Determinations in the Norwegian-Greenland Sea, An Assessment of Recent Results, Fourth Discussion Meeting on the Blue Road Geotraverse, Berlin Free University, Feb. 1981.

Wagner, C.A., and F. Lerch, The Accuracy of Geopotential Models, Planet. Space Sci., Vol 26, pp. 1081-1140, 1978.

Appendix

Fully Normalized Potential Coefficients

And Their Accuracy For New Combination Solution

L	$\bar{C}$(L)	SIGMA $\bar{C}$(L)	L	$\bar{C}$(L)	SIGMA $\bar{C}$(L)	L	$\bar{C}$(L)	SIGMA $\bar{C}$(L)
2	-484.1653	0.0004	3	0.9579	0.0002	4	0.5414	0.0012
5	0.0696	0.0007	6	-0.1493	0.0017	7	0.0913	0.0013
8	0.0522	0.0020	9	0.0260	0.0016	10	0.0530	0.0018
11	-0.0429	0.0018	12	0.0374	0.0025	13	0.0399	0.0027
14	-0.0255	0.0032	15	0.0045	0.0025	16	-0.0040	0.0032
17	0.0280	0.0022	18	0.0106	0.0025	19	0.0007	0.0026
20	0.0206	0.0026	21	-0.0003	0.0025	22	-0.0010	0.0033
23	-0.0188	0.0026	24	-0.0057	0.0032	25	0.0001	0.0032
26	0.0059	0.0025	27	0.0042	0.0025	28	-0.0133	0.0035
29	0.0005	0.0030	30	0.0144	0.0033	31	0.0008	0.0030
32	-0.0023	0.0019	33	-0.0031	0.0023	34	-0.0009	0.0011
35	0.0053	0.0020	36	-0.0014	0.0013	37	-0.0034	0.0024
38	-0.0022	0.0024	39	0.0005	0.0020	40	-0.0056	0.0022
41	0.0007	0.0009	42	0.0005	0.0020	43	0.0073	0.0024
44	0.0006	0.0023	45	-0.0061	0.0023	46	-0.0028	0.0022
47	0.0020	0.0022	48	0.0010	0.0021	49	-0.0010	0.0021
50	-0.0023	0.0020						

NOTE: ALL VALUES TO BE MULTIPLIED BY 10**6

L	M	$\bar{C}$(L,M)	$\bar{S}$(L,M)	SIGMA $\bar{C}$	SIGMA $\bar{S}$	L	M	$\bar{C}$(L,M)	$\bar{S}$(L,M)	SIGMA $\bar{C}$	SIGMA $\bar{S}$
2	1	-0.0007	-0.0015	0.0015	0.0014	2	2	2.4365	-1.4002	0.0010	0.0010
3	1	2.0236	0.2493	0.0026	0.0024	3	2	0.9027	-0.6153	0.0038	0.0036
3	3	0.7186	1.4168	0.0035	0.0035	4	1	-0.5363	-0.4743	0.0039	0.0038
4	2	0.3501	0.6602	0.0037	0.0038	4	3	0.9942	-0.2022	0.0027	0.0027
4	4	-0.1923	0.3056	0.0026	0.0026	5	1	-0.0519	-0.1032	0.0053	0.0056
5	2	0.6420	-0.3293	0.0074	0.0076	5	3	-0.4561	-0.2175	0.0069	0.0066
5	4	-0.2899	0.0498	0.0060	0.0041	5	5	0.1733	-0.6610	0.0060	0.0060
6	1	-0.0715	0.0212	0.0062	0.0058	6	2	0.0510	-0.3617	0.0063	0.0067
6	3	0.0562	0.0017	0.0056	0.0013	6	4	-0.0917	-0.4687	0.0058	0.0058
6	5	-0.2038	-0.5362	0.0035	0.0034	6	6	0.0069	-0.2371	0.0023	0.0023
7	1	0.2096	0.0878	0.0074	0.0076	7	2	0.3664	0.1151	0.0096	0.0089
7	3	0.2413	-0.2066	0.0077	0.0097	7	4	-0.2721	-0.1261	0.0090	0.0075
7	5	0.0125	0.0190	0.0072	0.0079	7	6	-0.3607	0.1518	0.0012	0.0012
7	7	0.0051	0.0215	0.0059	0.0057	8	1	0.0139	0.0483	0.0073	0.0068
8	2	0.0986	0.0665	0.0086	0.0091	8	3	-0.0162	-0.0682	0.0080	0.0078
8	4	-0.2438	0.0762	0.0048	0.0053	8	5	-0.0194	0.0833	0.0052	0.0063
8	6	-0.0664	0.3110	0.0053	0.0053	8	7	0.0696	0.0732	0.0040	0.0041
8	8	-0.1190	0.1095	0.0075	0.0075	9	1	0.1652	0.0254	0.0085	0.0079
9	2	0.0369	-0.0341	0.0076	0.0083	9	3	-0.1696	-0.0489	0.0073	0.0102
9	4	-0.0142	0.0312	0.0097	0.0095	9	5	-0.0273	-0.0339	0.0090	0.0089
9	6	0.0577	0.2106	0.0080	0.0081	9	7	-0.1028	-0.1003	0.0084	0.0083
9	8	0.1945	0.0012	0.0069	0.0070	9	9	-0.0449	0.0830	0.0072	0.0072
10	1	0.0922	-0.1084	0.0073	0.0063	10	2	-0.0797	-0.0559	0.0088	0.0093
10	3	-0.0218	-0.1500	0.0087	0.0084	10	4	-0.1013	-0.0912	0.0086	0.0066
10	5	-0.0588	-0.0411	0.0055	0.0049	10	6	-0.0437	-0.0835	0.0045	0.0038
10	7	0.0209	-0.0026	0.0067	0.0066	10	8	0.0487	-0.0720	0.0056	0.0074
10	9	0.1243	-0.0409	0.0027	0.0054	10	10	0.1075	-0.0279	0.0034	0.0072
11	1	-0.0005	-0.0035	0.0082	0.0083	11	2	0.0164	-0.1000	0.0086	0.0085
11	3	-0.0521	-0.1181	0.0083	0.0091	11	4	-0.0495	-0.0985	0.0088	0.0088
11	5	0.0446	0.0349	0.0087	0.0087	11	6	-0.0098	0.0357	0.0068	0.0072
11	7	0.0177	-0.0938	0.0080	0.0072	11	8	0.0204	0.0444	0.0069	0.0076
11	9	-0.0312	0.0565	0.0034	0.0067	11	10	-0.0487	-0.0169	0.0061	0.0064
11	11	0.0649	-0.0572	0.0083	0.0083	12	1	-0.0540	-0.0519	0.0070	0.0067
12	2	-0.0143	0.0067	0.0075	0.0082	12	3	0.0591	0.0283	0.0077	0.0075
12	4	-0.0797	0.0007	0.0064	0.0062	12	5	0.0451	0.0089	0.0061	0.0058
12	6	0.0060	0.0354	0.0072	0.0035	12	7	-0.0202	0.0270	0.0055	0.0071
12	8	-0.0199	0.0286	0.0055	0.0049	12	9	0.0398	0.0306	0.0032	0.0053
12	10	0.0029	0.0326	0.0043	0.0062	12	11	0.0124	-0.0070	0.0042	0.0018
12	12	-0.0016	-0.0006	0.0030	0.0030	13	1	-0.0346	0.0204	0.0071	0.0068
13	2	0.0314	-0.0788	0.0075	0.0076	13	3	-0.0262	0.0748	0.0068	0.0070
13	4	-0.0038	-0.0185	0.0072	0.0070	13	5	0.0659	0.0745	0.0068	0.0070
13	6	-0.0235	0.0026	0.0065	0.0069	13	7	-0.0024	-0.0129	0.0074	0.0063
13	8	-0.0155	-0.0012	0.0057	0.0045	13	9	-0.0037	0.0551	0.0064	0.0055
13	10	0.0364	-0.0429	0.0064	0.0061	13	11	-0.0288	-0.0109	0.0065	0.0054
13	12	-0.0287	0.0882	0.0022	0.0021	13	13	-0.0620	0.0666	0.0009	0.0009
14	1	-0.0047	0.0174	0.0067	0.0065	14	2	-0.0391	-0.0040	0.0055	0.0069
14	3	0.0471	-0.0043	0.0070	0.0065	14	4	0.0034	-0.0259	0.0063	0.0070
14	5	0.0230	-0.0150	0.0058	0.0050	14	6	-0.0134	0.0041	0.0070	0.0049
14	7	0.0277	0.0002	0.0063	0.0066	14	8	-0.0350	-0.0090	0.0063	0.0058
14	9	0.0182	0.0269	0.0056	0.0053	14	10	0.0165	-0.0042	0.0063	0.0058
14	11	0.0214	-0.0392	0.0048	0.0041	14	12	0.0094	-0.0331	0.0018	0.0018
14	13	0.0292	0.0450	0.0018	0.0011	14	14	-0.0498	-0.0057	0.0018	0.0020
15	1	0.0101	-0.0002	0.0060	0.0052	15	2	-0.0095	-0.0103	0.0063	0.0066
15	3	0.0456	0.0249	0.0063	0.0065	15	4	-0.0279	0.0031	0.0066	0.0058
15	5	0.0042	0.0064	0.0062	0.0050	15	6	0.0245	-0.0402	0.0060	0.0053
15	7	0.0553	0.0109	0.0052	0.0055	15	8	-0.0365	0.0251	0.0058	0.0040

NOTE: ALL VALUES TO BE MULTIPLIED BY 10**6

L	M	$\bar{C}$(L,M)	$\bar{S}$(L,M)	SIGMA $\bar{C}$	SIGMA $\bar{S}$	L	M	$\bar{C}$(L,M)	$\bar{S}$(L,M)	SIGMA $\bar{C}$	SIGMA $\bar{S}$
15	9	0.0110	0.0375	0.0048	0.0056	15	10	0.0056	0.0062	0.0062	0.0054
15	11	-0.0039	0.0131	0.0050	0.0060	15	12	-0.0302	0.0185	0.0026	0.0026
15	13	-0.0246	-0.0046	0.0012	0.0010	15	14	0.0040	-0.0240	0.0005	0.0003
15	15	-0.0227	-0.0073	0.0006	0.0006	16	1	0.0175	0.0269	0.0058	0.0058
16	2	-0.0175	0.0353	0.0061	0.0061	16	3	-0.0248	-0.0165	0.0054	0.0061
16	4	0.0372	0.0627	0.0050	0.0063	16	5	-0.0117	0.0122	0.0056	0.0060
16	6	0.0011	-0.0456	0.0061	0.0054	16	7	-0.0092	-0.0153	0.0050	0.0054
16	8	-0.0392	0.0038	0.0061	0.0061	16	9	-0.0239	-0.0503	0.0057	0.0057
16	10	0.0013	0.0058	0.0058	0.0040	16	11	0.0278	-0.0064	0.0053	0.0053
16	12	0.0179	0.0030	0.0027	0.0032	16	13	0.0139	0.0002	0.0017	0.0013
16	14	-0.0200	-0.0375	0.0020	0.0019	16	15	-0.0133	-0.0240	0.0025	0.0016
16	16	-0.0451	0.0050	0.0058	0.0057	17	1	-0.0320	-0.0200	0.0054	0.0055
17	2	-0.0207	0.0172	0.0053	0.0050	17	3	0.0032	0.0092	0.0052	0.0031
17	4	-0.0131	0.0170	0.0060	0.0058	17	5	-0.0159	0.0086	0.0040	0.0047
17	6	-0.0168	-0.0355	0.0052	0.0060	17	7	0.0321	-0.0125	0.0053	0.0055
17	8	0.0338	-0.0021	0.0057	0.0032	17	9	0.0001	-0.0359	0.0044	0.0046
17	10	0.0078	0.0132	0.0058	0.0047	17	11	-0.0083	0.0097	0.0054	0.0051
17	12	0.0262	0.0222	0.0022	0.0021	17	13	0.0144	0.0184	0.0016	0.0017
17	14	-0.0155	0.0122	0.0006	0.0007	17	15	0.0101	0.0068	0.0010	0.0012
17	16	-0.0284	0.0045	0.0034	0.0038	17	17	-0.0358	-0.0155	0.0056	0.0056
18	1	-0.0132	-0.0266	0.0053	0.0052	18	2	-0.0057	0.0121	0.0055	0.0051
18	3	-0.0006	-0.0067	0.0051	0.0042	18	4	0.0318	0.0107	0.0055	0.0050
18	5	0.0038	0.0114	0.0048	0.0053	18	6	0.0142	-0.0170	0.0027	0.0035
18	7	0.0076	0.0021	0.0051	0.0035	18	8	0.0354	0.0035	0.0056	0.0048
18	9	-0.0215	0.0251	0.0016	0.0033	18	10	0.0225	0.0005	0.0054	0.0043
18	11	-0.0121	0.0102	0.0034	0.0051	18	12	-0.0280	-0.0161	0.0037	0.0039
18	13	-0.0108	-0.0350	0.0025	0.0016	18	14	-0.0104	-0.0126	0.0019	0.0019
18	15	-0.0438	-0.0220	0.0017	0.0012	18	16	0.0127	0.0165	0.0036	0.0040
18	17	0.0127	0.0053	0.0055	0.0038	18	18	-0.0058	-0.0085	0.0057	0.0057
19	1	-0.0184	0.0047	0.0047	0.0051	19	2	0.0210	0.0015	0.0049	0.0045
19	3	-0.0130	-0.0121	0.0053	0.0047	19	4	0.0115	-0.0057	0.0049	0.0028
19	5	0.0072	0.0084	0.0041	0.0053	19	6	-0.0040	0.0214	0.0043	0.0051
19	7	0.0073	-0.0044	0.0046	0.0040	19	8	0.0295	0.0009	0.0049	0.0048
19	9	0.0075	-0.0033	0.0036	0.0050	19	10	-0.0107	-0.0076	0.0051	0.0020
19	11	0.0089	0.0254	0.0045	0.0050	19	12	-0.0117	-0.0063	0.0022	0.0021
19	13	-0.0102	-0.0315	0.0031	0.0026	19	14	-0.0057	-0.0115	0.0009	0.0009
19	15	-0.0142	-0.0128	0.0008	0.0009	19	16	-0.0279	-0.0134	0.0034	0.0035
19	17	0.0310	-0.0153	0.0046	0.0046	19	18	0.0407	-0.0140	0.0050	0.0039
19	19	-0.0036	0.0024	0.0051	0.0045	20	1	-0.0029	-0.0109	0.0044	0.0044
20	2	0.0125	0.0077	0.0044	0.0042	20	3	-0.0055	0.0141	0.0041	0.0039
20	4	0.0023	-0.0183	0.0027	0.0047	20	5	-0.0018	-0.0122	0.0026	0.0042
20	6	0.0132	-0.0009	0.0045	0.0027	20	7	-0.0134	0.0007	0.0024	0.0033
20	8	0.0041	0.0149	0.0042	0.0046	20	9	0.0132	0.0006	0.0044	0.0049
20	10	-0.0226	-0.0063	0.0046	0.0028	20	11	0.0157	-0.0089	0.0042	0.0027
20	12	-0.0100	0.0170	0.0030	0.0030	20	13	0.0262	0.0045	0.0027	0.0021
20	14	0.0121	-0.0116	0.0019	0.0020	20	15	-0.0238	-0.0046	0.0021	0.0015
20	16	-0.0111	-0.0041	0.0034	0.0037	20	17	0.0002	-0.0076	0.0045	0.0037
20	18	0.0062	-0.0024	0.0042	0.0050	20	19	0.0025	0.0101	0.0047	0.0028
20	20	0.0061	-0.0048	0.0047	0.0036	21	1	-0.0172	0.0237	0.0028	0.0046
21	2	0.0037	0.0017	0.0046	0.0038	21	3	0.0155	0.0132	0.0044	0.0038
21	4	-0.0012	0.0057	0.0043	0.0035	21	5	0.0030	-0.0064	0.0019	0.0016
21	6	-0.0034	0.0008	0.0043	0.0040	21	7	-0.0076	0.0096	0.0023	0.0033
21	8	-0.0031	0.0048	0.0040	0.0029	21	9	0.0145	0.0154	0.0037	0.0046
21	10	-0.0079	0.0001	0.0030	0.0031	21	11	0.0049	-0.0249	0.0045	0.0044
21	12	-0.0104	0.0096	0.0019	0.0020	21	13	-0.0151	0.0111	0.0019	0.0025
21	14	0.0203	0.0032	0.0017	0.0018	21	15	0.0157	0.0090	0.0007	0.0008

NOTE: ALL VALUES TO BE MULTIPLIED BY 10**6

L	M	C(L,M)	S(L,M)	SIGMA C	SIGMA S	L	M	C(L,M)	S(L,M)	SIGMA C	SIGMA S
21	16	0.0110	-0.0058	0.0041	0.0040	21	17	-0.0005	-0.0043	0.0022	0.0024
21	18	0.0193	-0.0072	0.0032	0.0037	21	19	-0.0285	0.0131	0.0044	0.0044
21	20	-0.0216	0.0171	0.0039	0.0038	21	21	0.0037	-0.0001	0.0036	0.0047
22	1	0.0052	0.0018	0.0032	0.0028	22	2	-0.0104	-0.0112	0.0044	0.0038
22	3	0.0061	0.0093	0.0037	0.0034	22	4	0.0063	0.0315	0.0043	0.0045
22	5	-0.0033	0.0007	0.0026	0.0033	22	6	0.0127	-0.0014	0.0044	0.0042
22	7	0.0078	0.0052	0.0037	0.0026	22	8	-0.0319	0.0029	0.0045	0.0021
22	9	0.0049	0.0123	0.0030	0.0042	22	10	0.0021	0.0227	0.0037	0.0044
22	11	-0.0067	-0.0221	0.0028	0.0023	22	12	-0.0139	-0.0107	0.0017	0.0017
22	13	-0.0193	0.0126	0.0025	0.0022	22	14	0.0081	0.0083	0.0028	0.0027
22	15	0.0245	0.0088	0.0018	0.0015	22	16	0.0010	-0.0080	0.0034	0.0026
22	17	0.0144	-0.0120	0.0043	0.0038	22	18	0.0151	-0.0091	0.0030	0.0021
22	19	0.0116	-0.0065	0.0044	0.0043	22	20	-0.0173	0.0228	0.0013	0.0037
22	21	-0.0273	0.0245	0.0042	0.0045	22	22	-0.0086	-0.0049	0.0037	0.0037
23	1	0.0057	0.0219	0.0023	0.0043	23	2	-0.0003	-0.0092	0.0017	0.0043
23	3	-0.0150	-0.0146	0.0039	0.0035	23	4	-0.0112	0.0069	0.0028	0.0038
23	5	0.0018	0.0093	0.0027	0.0034	23	6	-0.0095	0.0221	0.0034	0.0040
23	7	-0.0033	0.0064	0.0041	0.0027	23	8	-0.0004	-0.0015	0.0031	0.0017
23	9	0.0008	-0.0121	0.0020	0.0039	23	10	0.0087	-0.0019	0.0039	0.0032
23	11	0.0031	0.0161	0.0020	0.0043	23	12	0.0123	-0.0180	0.0022	0.0021
23	13	-0.0023	-0.0037	0.0030	0.0030	23	14	0.0074	-0.0012	0.0023	0.0023
23	15	0.0143	-0.0006	0.0015	0.0018	23	16	0.0063	0.0048	0.0026	0.0036
23	17	-0.0032	-0.0145	0.0035	0.0040	23	18	0.0127	-0.0078	0.0036	0.0036
23	19	-0.0037	0.0067	0.0031	0.0038	23	20	0.0075	-0.0074	0.0023	0.0038
23	21	0.0129	0.0136	0.0034	0.0040	23	22	-0.0212	0.0003	0.0043	0.0009
23	23	0.0010	-0.0119	0.0035	0.0034	24	1	-0.0065	-0.0002	0.0010	0.0035
24	2	0.0014	0.0139	0.0037	0.0040	24	3	-0.0061	0.0008	0.0037	0.0036
24	4	0.0060	0.0046	0.0037	0.0035	24	5	-0.0045	-0.0082	0.0038	0.0037
24	6	0.0014	0.0000	0.0034	0.0036	24	7	-0.0020	0.0041	0.0022	0.0035
24	8	0.0126	-0.0045	0.0039	0.0031	24	9	-0.0118	-0.0221	0.0033	0.0042
24	10	0.0079	0.0253	0.0033	0.0038	24	11	0.0084	0.0200	0.0025	0.0038
24	12	0.0192	-0.0036	0.0022	0.0022	24	13	0.0014	0.0026	0.0024	0.0026
24	14	-0.0189	0.0040	0.0034	0.0033	24	15	0.0015	-0.0173	0.0028	0.0026
24	16	0.0049	0.0019	0.0034	0.0024	24	17	-0.0097	-0.0078	0.0039	0.0035
24	18	0.0012	-0.0026	0.0034	0.0033	24	19	-0.0107	-0.0028	0.0039	0.0008
24	20	-0.0046	0.0007	0.0026	0.0029	24	21	0.0053	0.0121	0.0022	0.0038
24	22	0.0019	-0.0049	0.0025	0.0037	24	23	-0.0028	-0.0082	0.0019	0.0030
24	24	0.0026	-0.0031	0.0034	0.0016	25	1	-0.0015	-0.0017	0.0038	0.0037
25	2	0.0133	0.0084	0.0036	0.0032	25	3	-0.0139	0.0003	0.0039	0.0036
25	4	0.0007	-0.0015	0.0037	0.0030	25	5	-0.0079	-0.0027	0.0037	0.0015
25	6	0.0066	0.0024	0.0037	0.0009	25	7	0.0038	-0.0118	0.0028	0.0032
25	8	0.0109	-0.0003	0.0035	0.0006	25	9	-0.0279	0.0118	0.0040	0.0035
25	10	0.0084	-0.0062	0.0040	0.0016	25	11	0.0014	0.0078	0.0036	0.0024
25	12	-0.0119	0.0025	0.0010	0.0011	25	13	0.0146	-0.0093	0.0036	0.0016
25	14	-0.0244	0.0115	0.0035	0.0036	25	15	-0.0102	-0.0027	0.0018	0.0021
25	16	0.0003	-0.0156	0.0027	0.0031	25	17	-0.0086	-0.0009	0.0031	0.0028
25	18	0.0008	-0.0069	0.0035	0.0036	25	19	0.0041	0.0172	0.0030	0.0039
25	20	-0.0152	-0.0006	0.0038	0.0023	25	21	0.0078	0.0034	0.0037	0.0033
25	22	-0.0127	-0.0002	0.0038	0.0019	25	23	0.0081	-0.0113	0.0034	0.0037
25	24	0.0079	-0.0076	0.0023	0.0033	25	25	0.0032	0.0052	0.0033	0.0035
26	1	-0.0015	-0.0063	0.0033	0.0030	26	2	-0.0067	0.0119	0.0037	0.0036
26	3	0.0020	0.0040	0.0016	0.0025	26	4	0.0091	-0.0056	0.0029	0.0032
26	5	0.0074	0.0034	0.0033	0.0032	26	6	0.0090	-0.0038	0.0031	0.0021
26	7	-0.0028	-0.0052	0.0026	0.0030	26	8	0.0009	-0.0033	0.0029	0.0019
26	9	-0.0093	0.0042	0.0035	0.0023	26	10	-0.0104	-0.0115	0.0036	0.0039
26	11	0.0011	0.0006	0.0032	0.0027	26	12	-0.0149	-0.0001	0.0032	0.0025

NOTE: ALL VALUES TO BE MULTIPLIED BY 10**6

L	M	C(L,M)	S(L,M)	SIGMA C	SIGMA S
26	13	-0.0025	0.0037	0.0029	0.0029
26	15	-0.0137	0.0048	0.0032	0.0033
26	17	-0.0069	0.0090	0.0031	0.0029
26	19	-0.0023	0.0056	0.0032	0.0020
26	21	-0.0045	0.0007	0.0027	0.0025
26	23	0.0015	0.0157	0.0026	0.0025
26	25	-0.0011	-0.0013	0.0008	0.0030
27	1	0.0005	-0.0046	0.0027	0.0026
27	3	0.0024	0.0016	0.0032	0.0025
27	5	0.0172	0.0087	0.0037	0.0033
27	7	-0.0082	-0.0006	0.0029	0.0006
27	9	0.0004	0.0167	0.0024	0.0030
27	11	0.0008	-0.0079	0.0017	0.0035
27	13	-0.0077	-0.0033	0.0021	0.0033
27	15	-0.0078	0.0043	0.0013	0.0018
27	17	0.0045	-0.0001	0.0017	0.0027
27	19	-0.0016	-0.0075	0.0034	0.0029
27	21	0.0055	-0.0057	0.0031	0.0032
27	23	-0.0006	-0.0114	0.0023	0.0031
27	25	0.0099	0.0043	0.0008	0.0019
27	27	0.0108	-0.0026	0.0034	0.0021
28	2	-0.0145	-0.0103	0.0034	0.0036
28	4	0.0022	0.0050	0.0034	0.0033
28	6	0.0036	0.0051	0.0029	0.0022
28	8	0.0015	-0.0022	0.0023	0.0014
28	10	-0.0086	0.0115	0.0032	0.0033
28	12	-0.0006	0.0066	0.0031	0.0032
28	14	-0.0066	-0.0103	0.0021	0.0022
28	16	-0.0026	-0.0127	0.0020	0.0029
28	18	0.0021	-0.0015	0.0029	0.0026
28	20	-0.0006	0.0030	0.0034	0.0026
28	22	-0.0015	-0.0028	0.0022	0.0034
28	24	0.0101	-0.0129	0.0032	0.0027
28	26	0.0081	-0.0012	0.0014	0.0011
28	28	0.0065	0.0057	0.0019	0.0026
29	2	-0.0001	-0.0011	0.0021	0.0031
29	4	-0.0249	0.0004	0.0034	0.0032
29	6	0.0071	0.0036	0.0025	0.0022
29	8	-0.0087	0.0092	0.0027	0.0032
29	10	0.0055	0.0016	0.0024	0.0011
29	12	-0.0015	-0.0010	0.0033	0.0031
29	14	-0.0020	-0.0009	0.0029	0.0032
29	16	0.0006	-0.0191	0.0026	0.0031
29	18	-0.0052	-0.0015	0.0029	0.0032
29	20	-0.0072	-0.0012	0.0028	0.0029
29	22	0.0129	0.0023	0.0032	0.0021
29	24	0.0010	-0.0043	0.0021	0.0026
29	26	0.0058	-0.0132	0.0032	0.0028
29	28	0.0084	-0.0053	0.0024	0.0021
30	1	0.0014	0.0040	0.0021	0.0016
30	3	-0.0009	-0.0146	0.0016	0.0032
30	5	0.0003	-0.0083	0.0028	0.0032
30	7	0.0074	0.0006	0.0030	0.0021
30	9	-0.0073	-0.0039	0.0026	0.0019
30	11	-0.0062	0.0045	0.0029	0.0030
30	13	0.0089	0.0016	0.0026	0.0021
26	14	0.0021	0.0065	0.0032	0.0031
26	16	0.0066	-0.0110	0.0039	0.0036
26	18	-0.0136	0.0078	0.0037	0.0034
26	20	0.0037	-0.0127	0.0031	0.0035
26	22	0.0116	0.0066	0.0035	0.0031
26	24	0.0052	0.0124	0.0035	0.0029
26	26	-0.0010	0.0055	0.0023	0.0030
27	2	0.0015	0.0002	0.0019	0.0034
27	4	-0.0030	0.0041	0.0031	0.0023
27	6	0.0055	0.0046	0.0028	0.0033
27	8	0.0042	-0.0148	0.0024	0.0032
27	10	-0.0102	0.0020	0.0033	0.0034
27	12	-0.0059	-0.0082	0.0030	0.0029
27	14	0.0078	0.0110	0.0034	0.0029
27	16	0.0047	-0.0038	0.0036	0.0021
27	18	-0.0060	0.0109	0.0017	0.0026
27	20	-0.0003	0.0013	0.0023	0.0015
27	22	-0.0049	0.0017	0.0022	0.0032
27	24	-0.0056	0.0007	0.0025	0.0015
27	26	-0.0041	-0.0054	0.0029	0.0030
28	1	-0.0018	0.0052	0.0012	0.0026
28	3	0.0002	0.0091	0.0009	0.0031
28	5	0.0057	-0.0110	0.0022	0.0034
28	7	-0.0007	0.0029	0.0033	0.0016
28	9	0.0082	-0.0041	0.0031	0.0030
28	11	-0.0001	-0.0017	0.0015	0.0034
28	13	0.0050	0.0046	0.0034	0.0025
28	15	-0.0157	-0.0051	0.0032	0.0024
28	17	0.0111	-0.0027	0.0034	0.0031
28	19	-0.0012	0.0198	0.0021	0.0034
28	21	0.0105	0.0033	0.0032	0.0017
28	23	0.0035	-0.0025	0.0029	0.0033
28	25	0.0010	-0.0166	0.0018	0.0024
28	27	-0.0057	0.0045	0.0032	0.0022
29	1	-0.0017	-0.0031	0.0031	0.0029
29	3	0.0012	-0.0064	0.0009	0.0025
29	5	-0.0021	0.0013	0.0014	0.0012
29	7	-0.0018	-0.0063	0.0025	0.0032
29	9	-0.0005	0.0036	0.0014	0.0020
29	11	-0.0037	0.0057	0.0025	0.0032
29	13	-0.0023	-0.0083	0.0030	0.0012
29	15	-0.0072	-0.0048	0.0016	0.0017
29	17	0.0034	-0.0018	0.0008	0.0024
29	19	-0.0066	0.0065	0.0030	0.0029
29	21	-0.0039	0.0002	0.0025	0.0018
29	23	-0.0074	0.0011	0.0033	0.0017
29	25	0.0042	0.0059	0.0031	0.0026
29	27	-0.0067	-0.0015	0.0027	0.0026
29	29	0.0073	-0.0078	0.0023	0.0026
30	2	-0.0131	0.0007	0.0032	0.0014
30	4	-0.0018	0.0009	0.0019	0.0027
30	6	0.0034	0.0061	0.0027	0.0025
30	8	0.0000	0.0107	0.0015	0.0029
30	10	-0.0017	-0.0048	0.0021	0.0019
30	12	0.0150	-0.0060	0.0032	0.0025
30	14	0.0089	0.0064	0.0030	0.0020

NOTE: ALL VALUES TO BE MULTIPLIED BY 10**6

L	M	C̄(L,M)	S̄(L,M)	SIGMA C̄	SIGMA S̄	L	M	C̄(L,M)	S̄(L,M)	SIGMA C̄	SIGMA S̄
30	15	-0.0013	-0.0005	0.0019	0.0031	30	16	-0.0083	0.0007	0.0029	0.0015
30	17	-0.0030	-0.0054	0.0021	0.0024	30	18	-0.0090	-0.0077	0.0030	0.0024
30	19	-0.0096	0.0015	0.0027	0.0016	30	20	-0.0039	0.0049	0.0022	0.0027
30	21	-0.0058	-0.0050	0.0023	0.0022	30	22	-0.0013	0.0005	0.0013	0.0020
30	23	0.0027	-0.0066	0.0024	0.0029	30	24	-0.0015	-0.0036	0.0028	0.0024
30	25	0.0019	-0.0158	0.0018	0.0031	30	26	0.0012	0.0106	0.0032	0.0030
30	27	-0.0061	0.0079	0.0027	0.0014	30	28	-0.0091	-0.0185	0.0016	0.0017
30	29	0.0050	0.0049	0.0013	0.0021	30	30	-0.0033	0.0075	0.0010	0.0010
31	1	0.0065	-0.0065	0.0026	0.0025	31	2	0.0057	0.0029	0.0024	0.0015
31	3	-0.0031	-0.0080	0.0017	0.0027	31	4	0.0086	-0.0059	0.0029	0.0008
31	5	-0.0013	0.0022	0.0024	0.0017	31	6	-0.0015	0.0025	0.0015	0.0010
31	7	0.0017	-0.0014	0.0024	0.0010	31	8	0.0011	0.0002	0.0003	0.0016
31	9	-0.0017	0.0024	0.0019	0.0004	31	10	-0.0029	-0.0037	0.0008	0.0019
31	11	-0.0001	0.0169	0.0011	0.0032	31	12	0.0028	0.0065	0.0023	0.0029
31	13	0.0066	0.0057	0.0032	0.0029	31	14	-0.0050	0.0035	0.0028	0.0028
31	15	0.0068	-0.0066	0.0022	0.0019	31	16	-0.0093	0.0056	0.0029	0.0027
31	17	-0.0038	0.0043	0.0020	0.0026	31	18	-0.0020	-0.0011	0.0025	0.0020
31	19	0.0015	0.0013	0.0022	0.0025	31	20	-0.0009	0.0031	0.0008	0.0030
31	21	-0.0038	0.0014	0.0029	0.0019	31	22	-0.0068	-0.0041	0.0018	0.0017
31	23	0.0081	0.0073	0.0023	0.0024	31	24	-0.0011	-0.0006	0.0015	0.0016
31	25	-0.0105	-0.0019	0.0028	0.0030	31	26	-0.0093	0.0006	0.0023	0.0028
31	27	0.0024	0.0134	0.0030	0.0032	31	28	0.0079	0.0022	0.0029	0.0029
31	29	-0.0035	-0.0045	0.0013	0.0031	31	30	-0.0016	-0.0037	0.0003	0.0025
31	31	-0.0043	0.0004	0.0014	0.0002	32	1	-0.0021	0.0049	0.0025	0.0019
32	2	0.0035	-0.0033	0.0025	0.0023	32	3	-0.0052	0.0028	0.0020	0.0005
32	4	0.0003	-0.0051	0.0008	0.0030	32	5	0.0030	0.0001	0.0010	0.0008
32	6	-0.0002	-0.0055	0.0004	0.0022	32	7	-0.0028	0.0003	0.0023	0.0004
32	8	0.0095	0.0072	0.0030	0.0027	32	9	0.0024	-0.0016	0.0018	0.0023
32	10	0.0014	-0.0062	0.0023	0.0025	32	11	-0.0025	0.0037	0.0012	0.0021
32	12	-0.0095	0.0148	0.0029	0.0030	32	13	0.0005	0.0075	0.0012	0.0026
32	14	-0.0037	0.0012	0.0027	0.0024	32	15	0.0048	-0.0051	0.0023	0.0028
32	16	0.0005	-0.0012	0.0024	0.0017	32	17	-0.0053	0.0068	0.0026	0.0019
32	18	0.0063	0.0009	0.0021	0.0019	32	19	-0.0005	-0.0006	0.0006	0.0024
32	20	0.0040	0.0023	0.0023	0.0028	32	21	-0.0027	0.0098	0.0018	0.0026
32	22	-0.0083	-0.0035	0.0025	0.0029	32	23	0.0046	-0.0018	0.0026	0.0015
32	24	-0.0092	0.0053	0.0028	0.0021	32	25	-0.0119	-0.0008	0.0026	0.0026
32	26	0.0016	-0.0012	0.0023	0.0028	32	27	-0.0065	-0.0089	0.0018	0.0025
32	28	0.0032	-0.0019	0.0021	0.0020	32	29	-0.0010	0.0041	0.0025	0.0027
32	30	-0.0067	0.0005	0.0028	0.0017	32	31	-0.0043	0.0002	0.0024	0.0007
32	32	0.0045	0.0010	0.0014	0.0020	33	1	-0.0029	-0.0030	0.0023	0.0026
33	2	-0.0030	0.0013	0.0020	0.0017	33	3	-0.0038	0.0022	0.0026	0.0018
33	4	-0.0019	0.0009	0.0027	0.0016	33	5	-0.0003	0.0058	0.0010	0.0020
33	6	-0.0000	-0.0015	0.0004	0.0002	33	7	-0.0071	-0.0002	0.0027	0.0003
33	8	0.0012	0.0084	0.0007	0.0026	33	9	-0.0016	0.0020	0.0019	0.0014
33	10	-0.0046	-0.0055	0.0027	0.0017	33	11	-0.0020	-0.0062	0.0018	0.0027
33	12	-0.0010	0.0089	0.0010	0.0026	33	13	0.0043	0.0034	0.0027	0.0012
33	14	-0.0001	0.0030	0.0012	0.0017	33	15	-0.0016	-0.0062	0.0021	0.0024
33	16	0.0010	0.0011	0.0017	0.0008	33	17	-0.0004	0.0075	0.0010	0.0016
33	18	-0.0043	-0.0031	0.0012	0.0022	33	19	0.0066	-0.0014	0.0022	0.0015
33	20	0.0005	-0.0029	0.0015	0.0013	33	21	0.0011	0.0056	0.0007	0.0027
33	22	-0.0047	-0.0130	0.0020	0.0028	33	23	-0.0023	-0.0110	0.0015	0.0028
33	24	0.0076	-0.0038	0.0028	0.0027	33	25	0.0034	-0.0083	0.0024	0.0024
33	26	0.0077	0.0066	0.0027	0.0025	33	27	-0.0031	-0.0034	0.0029	0.0024
33	28	-0.0004	-0.0014	0.0024	0.0023	33	29	-0.0173	0.0065	0.0019	0.0031
33	30	-0.0016	-0.0199	0.0011	0.0007	33	31	0.0033	-0.0003	0.0015	0.0002
33	32	0.0054	-0.0038	0.0028	0.0021	33	33	0.0019	0.0042	0.0020	0.0020

NOTE: ALL VALUES TO BE MULTIPLIED BY 10**6

L	M	C(L,M)	S(L,M)	SIGMA C	SIGMA S	L	M	C(L,M)	S(L,M)	SIGMA C	SIGMA S
34	1	-0.0013	0.0005	0.0018	0.0025	34	2	0.0004	0.0015	0.0001	0.0010
34	3	0.0123	0.0066	0.0028	0.0027	34	4	-0.0025	-0.0002	0.0015	0.0005
34	5	-0.0027	0.0020	0.0013	0.0002	34	6	0.0056	0.0082	0.0017	0.0025
34	7	-0.0003	-0.0013	0.0011	0.0005	34	8	-0.0115	0.0022	0.0029	0.0011
34	9	0.0004	0.0008	0.0003	0.0017	34	10	-0.0083	-0.0012	0.0026	0.0020
34	11	-0.0020	-0.0011	0.0016	0.0015	34	12	0.0101	-0.0044	0.0027	0.0026
34	13	-0.0015	0.0030	0.0025	0.0020	34	14	-0.0031	0.0096	0.0023	0.0026
34	15	0.0002	0.0062	0.0023	0.0024	34	16	-0.0024	-0.0035	0.0009	0.0018
34	17	-0.0031	0.0006	0.0015	0.0007	34	18	-0.0097	-0.0040	0.0023	0.0019
34	19	0.0013	0.0029	0.0023	0.0016	34	20	0.0045	-0.0038	0.0020	0.0021
34	21	0.0001	-0.0052	0.0012	0.0015	34	22	-0.0018	0.0052	0.0021	0.0019
34	23	0.0006	-0.0066	0.0004	0.0025	34	24	0.0076	0.0014	0.0020	0.0021
34	25	0.0050	-0.0077	0.0017	0.0027	34	26	0.0023	-0.0094	0.0023	0.0023
34	27	0.0115	-0.0022	0.0025	0.0022	34	28	-0.0001	-0.0192	0.0024	0.0024
34	29	0.0036	-0.0063	0.0026	0.0025	34	30	-0.0229	-0.0006	0.0028	0.0025
34	31	-0.0011	0.0002	0.0009	0.0018	34	32	0.0044	-0.0002	0.0024	0.0002
34	33	0.0120	0.0024	0.0028	0.0011	34	34	-0.0051	-0.0004	0.0023	0.0008
35	1	-0.0032	-0.0110	0.0022	0.0026	35	2	-0.0112	0.0017	0.0025	0.0015
35	3	0.0060	0.0001	0.0023	0.0014	35	4	-0.0016	0.0015	0.0016	0.0020
35	5	-0.0044	-0.0027	0.0018	0.0020	35	6	0.0032	0.0064	0.0023	0.0026
35	7	-0.0022	0.0022	0.0022	0.0003	35	8	0.0021	0.0028	0.0006	0.0010
35	9	-0.0004	-0.0008	0.0011	0.0018	35	10	-0.0035	0.0049	0.0014	0.0023
35	11	0.0010	-0.0012	0.0019	0.0020	35	12	0.0047	-0.0041	0.0022	0.0026
35	13	0.0020	0.0036	0.0018	0.0021	35	14	-0.0054	-0.0057	0.0027	0.0022
35	15	-0.0135	0.0055	0.0024	0.0019	35	16	-0.0044	-0.0056	0.0024	0.0022
35	17	0.0022	-0.0068	0.0011	0.0019	35	18	-0.0024	-0.0058	0.0008	0.0025
35	19	-0.0004	-0.0027	0.0018	0.0006	35	20	0.0006	0.0016	0.0014	0.0016
35	21	0.0085	0.0003	0.0027	0.0012	35	22	0.0011	0.0009	0.0007	0.0012
35	23	-0.0048	-0.0000	0.0018	0.0014	35	24	0.0021	0.0011	0.0016	0.0014
35	25	0.0062	0.0034	0.0026	0.0016	35	26	-0.0041	-0.0002	0.0014	0.0020
35	27	0.0060	-0.0165	0.0021	0.0029	35	28	0.0107	-0.0160	0.0028	0.0029
35	29	0.0097	0.0025	0.0016	0.0023	35	30	-0.0039	0.0059	0.0016	0.0021
35	31	0.0016	0.0024	0.0012	0.0020	35	32	-0.0014	-0.0067	0.0016	0.0024
35	33	0.0035	-0.0019	0.0010	0.0012	35	34	-0.0018	0.0018	0.0010	0.0001
35	35	-0.0056	-0.0044	0.0023	0.0025	36	1	0.0024	0.0033	0.0024	0.0023
36	2	-0.0072	-0.0008	0.0025	0.0024	36	3	0.0013	-0.0094	0.0003	0.0024
36	4	0.0017	-0.0012	0.0006	0.0019	36	5	-0.0045	-0.0000	0.0017	0.0020
36	6	0.0138	-0.0015	0.0026	0.0016	36	7	-0.0004	0.0059	0.0004	0.0024
36	8	0.0001	-0.0036	0.0019	0.0020	36	9	0.0010	-0.0002	0.0010	0.0008
36	10	-0.0002	0.0052	0.0005	0.0024	36	11	0.0005	0.0003	0.0021	0.0020
36	12	-0.0003	-0.0047	0.0004	0.0021	36	13	-0.0053	0.0038	0.0025	0.0016
36	14	-0.0059	-0.0062	0.0020	0.0017	36	15	-0.0006	0.0019	0.0015	0.0013
36	16	0.0008	-0.0018	0.0008	0.0007	36	17	0.0061	-0.0076	0.0019	0.0024
36	18	0.0010	0.0049	0.0014	0.0023	36	19	-0.0055	-0.0013	0.0023	0.0010
36	20	-0.0040	0.0020	0.0021	0.0008	36	21	0.0036	-0.0030	0.0020	0.0014
36	22	0.0007	-0.0018	0.0020	0.0017	36	23	0.0003	-0.0009	0.0007	0.0003
36	24	0.0014	-0.0007	0.0005	0.0016	36	25	-0.0013	0.0126	0.0018	0.0026
36	26	0.0044	0.0048	0.0026	0.0020	36	27	-0.0083	0.0086	0.0025	0.0025
36	28	0.0018	-0.0032	0.0013	0.0018	36	29	0.0044	-0.0014	0.0024	0.0026
36	30	-0.0060	0.0046	0.0026	0.0023	36	31	-0.0070	-0.0050	0.0026	0.0026
36	32	0.0056	0.0011	0.0018	0.0011	36	33	0.0029	-0.0031	0.0014	0.0023
36	34	-0.0050	0.0026	0.0024	0.0018	36	35	0.0007	-0.0085	0.0010	0.0025
36	36	0.0013	-0.0016	0.0016	0.0015	37	1	0.0005	-0.0020	0.0028	0.0028
37	2	0.0011	-0.0113	0.0028	0.0028	37	3	0.0001	0.0006	0.0028	0.0028
37	4	0.0057	-0.0014	0.0028	0.0028	37	5	-0.0060	0.0079	0.0028	0.0028
37	6	-0.0025	0.0062	0.0028	0.0026	37	7	0.0064	0.0064	0.0028	0.0028

NOTE: ALL VALUES TO BE MULTIPLIED BY 10**6

L	M	C̄(L,M)	S̄(L,M)	SIGMA C̄	SIGMA S̄	L	M	C̄(L,M)	S̄(L,M)	SIGMA C̄	SIGMA S̄
37	8	-0.0055	-0.0038	0.0028	0.0028	37	9	0.0006	-0.0047	0.0028	0.0028
37	10	-0.0000	0.0031	0.0028	0.0028	37	11	0.0031	0.0026	0.0028	0.0028
37	12	0.0012	0.0001	0.0028	0.0028	37	13	-0.0002	-0.0097	0.0028	0.0028
37	14	-0.0052	-0.0020	0.0028	0.0028	37	15	0.0073	-0.0007	0.0028	0.0028
37	16	0.0022	0.0136	0.0028	0.0028	37	17	0.0052	-0.0039	0.0028	0.0028
37	18	0.0024	0.0012	0.0028	0.0028	37	19	-0.0072	0.0029	0.0028	0.0028
37	20	-0.0089	-0.0034	0.0028	0.0028	37	21	0.0031	-0.0009	0.0028	0.0028
37	22	0.0062	0.0029	0.0028	0.0028	37	23	0.0011	0.0006	0.0028	0.0028
37	24	-0.0038	-0.0059	0.0028	0.0028	37	25	0.0033	-0.0019	0.0028	0.0028
37	26	-0.0001	0.0066	0.0028	0.0028	37	27	-0.0028	0.0050	0.0028	0.0028
37	28	0.0123	0.0048	0.0028	0.0028	37	29	0.0053	0.0046	0.0028	0.0028
37	30	-0.0083	0.0140	0.0028	0.0028	37	31	0.0045	-0.0082	0.0028	0.0028
37	32	-0.0001	0.0019	0.0028	0.0028	37	33	-0.0002	-0.0210	0.0028	0.0028
37	34	0.0050	0.0031	0.0028	0.0028	37	35	-0.0071	-0.0077	0.0028	0.0028
37	36	-0.0031	-0.0033	0.0028	0.0028	37	37	0.0065	-0.0035	0.0028	0.0028
38	1	0.0043	0.0023	0.0027	0.0027	38	2	0.0063	0.0041	0.0027	0.0027
38	3	0.0042	0.0007	0.0027	0.0027	38	4	0.0026	-0.0006	0.0027	0.0027
38	5	-0.0068	0.0077	0.0027	0.0027	38	6	-0.0137	0.0037	0.0027	0.0027
38	7	-0.0011	-0.0068	0.0027	0.0027	38	8	0.0038	0.0019	0.0027	0.0027
38	9	0.0070	-0.0018	0.0027	0.0027	38	10	-0.0030	-0.0046	0.0027	0.0027
38	11	0.0018	0.0080	0.0027	0.0027	38	12	0.0015	-0.0010	0.0027	0.0027
38	13	-0.0009	-0.0097	0.0027	0.0027	38	14	-0.0066	0.0041	0.0027	0.0027
38	15	0.0006	-0.0006	0.0027	0.0027	38	16	-0.0076	0.0106	0.0027	0.0027
38	17	0.0031	0.0045	0.0027	0.0027	38	18	0.0093	-0.0033	0.0027	0.0027
38	19	0.0005	-0.0009	0.0027	0.0027	38	20	0.0022	-0.0026	0.0027	0.0027
38	21	-0.0001	-0.0013	0.0027	0.0027	38	22	0.0017	0.0064	0.0027	0.0027
38	23	0.0012	0.0046	0.0027	0.0027	38	24	-0.0086	0.0022	0.0027	0.0027
38	25	0.0005	0.0035	0.0027	0.0027	38	26	-0.0054	0.0031	0.0027	0.0027
38	27	-0.0029	0.0098	0.0027	0.0027	38	28	-0.0066	-0.0008	0.0027	0.0027
38	29	0.0061	0.0057	0.0027	0.0027	38	30	0.0005	0.0025	0.0001	0.0022
38	31	0.0025	-0.0035	0.0027	0.0027	38	32	0.0059	0.0016	0.0027	0.0027
38	33	0.0083	0.0130	0.0027	0.0027	38	34	-0.0070	0.0009	0.0027	0.0027
38	35	0.0065	0.0056	0.0027	0.0027	38	36	0.0016	0.0007	0.0027	0.0027
38	37	-0.0039	0.0016	0.0027	0.0027	38	38	0.0050	-0.0014	0.0027	0.0027
39	1	0.0008	0.0049	0.0026	0.0026	39	2	0.0035	0.0077	0.0026	0.0026
39	3	-0.0023	0.0059	0.0026	0.0026	39	4	-0.0078	-0.0087	0.0026	0.0026
39	5	0.0062	0.0073	0.0026	0.0026	39	6	-0.0048	0.0009	0.0026	0.0026
39	7	0.0017	-0.0052	0.0026	0.0026	39	8	0.0008	0.0098	0.0026	0.0026
39	9	0.0078	0.0072	0.0026	0.0026	39	10	-0.0027	0.0050	0.0026	0.0026
39	11	0.0116	-0.0017	0.0026	0.0026	39	12	-0.0030	0.0129	0.0026	0.0026
39	13	-0.0039	-0.0014	0.0026	0.0026	39	14	-0.0045	0.0017	0.0026	0.0026
39	15	-0.0046	0.0007	0.0026	0.0026	39	16	0.0013	-0.0019	0.0026	0.0026
39	17	-0.0016	-0.0007	0.0026	0.0026	39	18	0.0032	0.0004	0.0026	0.0026
39	19	0.0057	0.0049	0.0026	0.0026	39	20	-0.0008	-0.0067	0.0026	0.0026
39	21	-0.0055	-0.0014	0.0026	0.0026	39	22	-0.0077	-0.0016	0.0026	0.0026
39	23	-0.0046	0.0020	0.0026	0.0026	39	24	-0.0081	0.0079	0.0026	0.0026
39	25	-0.0049	-0.0022	0.0026	0.0026	39	26	-0.0027	0.0090	0.0026	0.0026
39	27	-0.0036	-0.0059	0.0026	0.0026	39	28	-0.0040	-0.0087	0.0026	0.0026
39	29	-0.0042	-0.0026	0.0026	0.0026	39	30	0.0038	-0.0113	0.0026	0.0026
39	31	0.0044	-0.0117	0.0026	0.0026	39	32	0.0007	0.0069	0.0026	0.0026
39	33	-0.0061	0.0030	0.0026	0.0026	39	34	0.0027	0.0034	0.0026	0.0026
39	35	-0.0143	0.0049	0.0026	0.0026	39	36	0.0024	-0.0019	0.0026	0.0026
39	37	0.0010	-0.0032	0.0026	0.0026	39	38	-0.0027	0.0034	0.0026	0.0026
39	39	0.0000	-0.0000	0.0006	0.0003	40	1	0.0006	0.0007	0.0026	0.0026
40	2	-0.0043	0.0029	0.0026	0.0026	40	3	-0.0004	0.0007	0.0026	0.0026
40	4	0.0020	-0.0075	0.0026	0.0026	40	5	0.0135	-0.0029	0.0026	0.0026

NOTE: ALL VALUES TO BE MULTIPLIED BY 10**6

L	M	$\bar{C}$(L,M)	$\bar{S}$(L,M)	SIGMA $\bar{C}$	SIGMA $\bar{S}$	L	M	$\bar{C}$(L,M)	$\bar{S}$(L,M)	SIGMA $\bar{C}$	SIGMA $\bar{S}$
40	6	-0.0015	0.0034	0.0026	0.0026	40	7	-0.0026	-0.0013	0.0026	0.0026
40	8	0.0059	0.0026	0.0026	0.0026	40	9	-0.0002	0.0013	0.0026	0.0026
40	10	-0.0048	0.0086	0.0026	0.0026	40	11	0.0006	-0.0014	0.0026	0.0026
40	12	0.0059	0.0028	0.0026	0.0026	40	13	-0.0057	-0.0021	0.0026	0.0026
40	14	-0.0032	0.0025	0.0026	0.0025	40	15	-0.0078	-0.0017	0.0026	0.0026
40	16	-0.0022	-0.0045	0.0026	0.0026	40	17	0.0030	-0.0027	0.0026	0.0026
40	18	0.0002	0.0014	0.0026	0.0026	40	19	-0.0018	-0.0042	0.0026	0.0026
40	20	-0.0024	0.0066	0.0026	0.0026	40	21	-0.0048	-0.0001	0.0026	0.0026
40	22	-0.0139	-0.0165	0.0026	0.0026	40	23	-0.0014	-0.0143	0.0026	0.0026
40	24	0.0023	0.0040	0.0026	0.0026	40	25	0.0008	-0.0034	0.0026	0.0026
40	26	0.0039	-0.0001	0.0026	0.0026	40	27	-0.0014	0.0002	0.0026	0.0026
40	28	0.0025	0.0047	0.0026	0.0026	40	29	0.0016	-0.0016	0.0026	0.0026
40	30	0.0012	-0.0015	0.0022	0.0022	40	31	-0.0016	-0.0011	0.0026	0.0026
40	32	-0.0007	-0.0029	0.0026	0.0026	40	33	-0.0034	-0.0031	0.0026	0.0026
40	34	0.0025	0.0028	0.0026	0.0026	40	35	0.0117	-0.0053	0.0026	0.0026
40	36	0.0009	0.0051	0.0026	0.0026	40	37	-0.0071	0.0012	0.0026	0.0026
40	38	-0.0004	0.0074	0.0026	0.0026	40	39	0.0044	0.0021	0.0024	0.0022
40	40	0.0001	-0.0002	0.0007	0.0009	41	1	-0.0015	-0.0068	0.0025	0.0025
41	2	0.0034	0.0024	0.0025	0.0025	41	3	0.0014	0.0044	0.0025	0.0025
41	4	-0.0041	0.0028	0.0025	0.0025	41	5	0.0055	-0.0015	0.0025	0.0025
41	6	0.0005	0.0010	0.0025	0.0025	41	7	0.0004	0.0017	0.0025	0.0025
41	8	-0.0054	-0.0045	0.0025	0.0025	41	9	-0.0066	0.0049	0.0025	0.0025
41	10	0.0034	-0.0002	0.0025	0.0025	41	11	0.0013	-0.0060	0.0025	0.0025
41	12	-0.0004	0.0013	0.0025	0.0025	41	13	-0.0034	0.0030	0.0025	0.0025
41	14	0.0043	0.0001	0.0025	0.0025	41	15	-0.0007	0.0008	0.0025	0.0025
41	16	-0.0009	-0.0058	0.0025	0.0025	41	17	-0.0026	0.0012	0.0025	0.0025
41	18	-0.0000	0.0045	0.0025	0.0025	41	19	-0.0046	-0.0014	0.0025	0.0025
41	20	0.0040	-0.0069	0.0025	0.0025	41	21	0.0000	-0.0006	0.0025	0.0025
41	22	-0.0093	-0.0023	0.0025	0.0025	41	23	0.0008	-0.0150	0.0025	0.0025
41	24	0.0069	0.0010	0.0025	0.0025	41	25	0.0006	0.0030	0.0025	0.0025
41	26	0.0045	-0.0071	0.0025	0.0025	41	27	-0.0017	0.0024	0.0025	0.0025
41	28	-0.0011	-0.0064	0.0025	0.0025	41	29	-0.0052	0.0058	0.0025	0.0025
41	30	0.0024	-0.0045	0.0025	0.0025	41	31	0.0108	0.0011	0.0025	0.0025
41	32	-0.0023	0.0070	0.0025	0.0025	41	33	-0.0053	0.0098	0.0025	0.0025
41	34	-0.0019	0.0005	0.0025	0.0025	41	35	-0.0144	0.0080	0.0025	0.0025
41	36	0.0007	0.0009	0.0025	0.0025	41	37	0.0016	-0.0118	0.0025	0.0025
41	38	-0.0135	0.0023	0.0025	0.0025	41	39	-0.0009	0.0000	0.0012	0.0006
41	40	0.0000	-0.0001	0.0002	0.0005	41	41	0.0026	0.0058	0.0020	0.0023
42	1	-0.0043	0.0015	0.0024	0.0024	42	2	-0.0036	-0.0034	0.0024	0.0024
42	3	0.0018	0.0084	0.0024	0.0024	42	4	0.0018	0.0015	0.0024	0.0024
42	5	-0.0069	-0.0091	0.0024	0.0024	42	6	0.0027	-0.0032	0.0024	0.0024
42	7	0.0027	-0.0068	0.0024	0.0024	42	8	0.0029	-0.0024	0.0024	0.0024
42	9	-0.0014	0.0019	0.0024	0.0024	42	10	0.0040	0.0036	0.0024	0.0024
42	11	0.0008	-0.0015	0.0024	0.0024	42	12	0.0038	-0.0062	0.0024	0.0024
42	13	-0.0023	0.0022	0.0024	0.0024	42	14	-0.0032	0.0056	0.0024	0.0024
42	15	-0.0025	0.0069	0.0024	0.0024	42	16	0.0068	-0.0044	0.0024	0.0024
42	17	-0.0033	-0.0041	0.0024	0.0024	42	18	-0.0072	0.0052	0.0024	0.0024
42	19	-0.0063	-0.0012	0.0024	0.0024	42	20	0.0078	-0.0003	0.0024	0.0024
42	21	0.0031	-0.0042	0.0024	0.0024	42	22	-0.0012	-0.0022	0.0024	0.0024
42	23	-0.0054	-0.0067	0.0024	0.0024	42	24	0.0051	0.0038	0.0024	0.0024
42	25	-0.0049	0.0008	0.0024	0.0024	42	26	0.0008	-0.0069	0.0024	0.0024
42	27	0.0048	-0.0010	0.0024	0.0024	42	28	-0.0040	0.0014	0.0024	0.0024
42	29	-0.0064	-0.0007	0.0024	0.0024	42	30	0.0045	0.0031	0.0010	0.0012
42	31	0.0037	0.0037	0.0024	0.0024	42	32	0.0079	0.0066	0.0024	0.0024
42	33	0.0015	0.0067	0.0024	0.0024	42	34	0.0041	0.0079	0.0024	0.0024
42	35	-0.0058	-0.0000	0.0024	0.0024	42	36	0.0030	-0.0033	0.0024	0.0024

NOTE: ALL VALUES TO BE MULTIPLIED BY 10**6

L	M	$\bar{C}$(L,M)	$\bar{S}$(L,M)	SIGMA $\bar{C}$	SIGMA $\bar{S}$	L	M	$\bar{C}$(L,M)	$\bar{S}$(L,M)	SIGMA $\bar{C}$	SIGMA $\bar{S}$
42	37	-0.0099	0.0044	0.0024	0.0024	42	38	0.0035	-0.0117	0.0024	0.0024
42	39	0.0001	0.0105	0.0012	0.0024	42	40	0.0000	-0.0014	0.0003	0.0016
42	41	0.0002	0.0003	0.0008	0.0009	42	42	-0.0068	0.0012	0.0022	0.0017
43	1	0.0000	0.0014	0.0024	0.0024	43	2	-0.0109	-0.0023	0.0024	0.0024
43	3	-0.0008	-0.0019	0.0024	0.0024	43	4	0.0024	0.0004	0.0024	0.0024
43	5	-0.0125	0.0027	0.0024	0.0024	43	6	0.0092	-0.0011	0.0024	0.0024
43	7	-0.0026	0.0005	0.0024	0.0024	43	8	-0.0035	-0.0000	0.0024	0.0024
43	9	0.0006	-0.0031	0.0024	0.0024	43	10	-0.0032	0.0016	0.0024	0.0024
43	11	-0.0031	0.0019	0.0024	0.0024	43	12	-0.0024	0.0004	0.0024	0.0024
43	13	0.0011	-0.0009	0.0024	0.0024	43	14	-0.0018	0.0024	0.0024	0.0024
43	15	0.0026	0.0082	0.0024	0.0024	43	16	0.0047	-0.0012	0.0024	0.0024
43	17	0.0023	-0.0021	0.0024	0.0024	43	18	0.0015	-0.0058	0.0024	0.0024
43	19	-0.0057	-0.0032	0.0024	0.0024	43	20	-0.0010	0.0022	0.0024	0.0024
43	21	0.0055	0.0053	0.0024	0.0024	43	22	0.0046	0.0008	0.0024	0.0024
43	23	0.0005	-0.0086	0.0024	0.0024	43	24	0.0065	-0.0003	0.0024	0.0024
43	25	-0.0002	0.0026	0.0024	0.0024	43	26	-0.0021	0.0012	0.0024	0.0024
43	27	0.0056	0.0009	0.0024	0.0024	43	28	-0.0036	0.0084	0.0024	0.0024
43	29	-0.0014	-0.0030	0.0024	0.0024	43	30	-0.0105	-0.0053	0.0024	0.0024
43	31	-0.0019	0.0010	0.0024	0.0024	43	32	-0.0035	0.0059	0.0024	0.0024
43	33	0.0045	0.0001	0.0024	0.0024	43	34	0.0003	-0.0011	0.0024	0.0024
43	35	0.0012	0.0062	0.0024	0.0024	43	36	-0.0015	-0.0024	0.0024	0.0024
43	37	0.0016	0.0039	0.0024	0.0024	43	38	-0.0069	0.0029	0.0024	0.0024
43	39	0.0005	-0.0024	0.0011	0.0020	43	40	0.0085	0.0001	0.0023	0.0006
43	41	-0.0029	0.0006	0.0017	0.0004	43	42	-0.0025	0.0027	0.0019	0.0020
43	43	-0.0001	-0.0050	0.0008	0.0019	44	1	0.0058	-0.0015	0.0023	0.0023
44	2	0.0016	0.0049	0.0023	0.0023	44	3	0.0049	-0.0093	0.0023	0.0023
44	4	0.0037	-0.0003	0.0023	0.0023	44	5	0.0033	0.0024	0.0023	0.0023
44	6	-0.0079	0.0025	0.0023	0.0023	44	7	0.0071	0.0095	0.0023	0.0023
44	8	-0.0082	-0.0002	0.0023	0.0023	44	9	0.0002	-0.0075	0.0023	0.0023
44	10	-0.0037	-0.0042	0.0023	0.0023	44	11	-0.0032	-0.0005	0.0023	0.0023
44	12	-0.0014	-0.0016	0.0023	0.0023	44	13	0.0045	-0.0042	0.0023	0.0023
44	14	0.0014	-0.0029	0.0023	0.0023	44	15	-0.0015	-0.0051	0.0023	0.0023
44	16	0.0045	0.0041	0.0023	0.0023	44	17	0.0060	0.0053	0.0023	0.0023
44	18	0.0055	-0.0041	0.0023	0.0023	44	19	0.0017	-0.0035	0.0023	0.0023
44	20	-0.0018	-0.0019	0.0023	0.0023	44	21	-0.0083	-0.0007	0.0023	0.0023
44	22	0.0081	0.0025	0.0023	0.0023	44	23	0.0025	0.0068	0.0023	0.0023
44	24	0.0030	-0.0034	0.0023	0.0023	44	25	0.0013	0.0011	0.0023	0.0023
44	26	-0.0057	0.0007	0.0023	0.0023	44	27	0.0036	-0.0013	0.0023	0.0023
44	28	-0.0016	0.0042	0.0023	0.0023	44	29	-0.0082	0.0032	0.0023	0.0023
44	30	0.0052	0.0006	0.0023	0.0023	44	31	-0.0014	0.0057	0.0023	0.0023
44	32	-0.0043	0.0021	0.0023	0.0023	44	33	-0.0033	0.0002	0.0023	0.0023
44	34	-0.0048	0.0048	0.0023	0.0023	44	35	-0.0072	-0.0033	0.0023	0.0023
44	36	0.0022	-0.0064	0.0023	0.0023	44	37	0.0127	0.0063	0.0023	0.0023
44	38	0.0031	-0.0068	0.0023	0.0023	44	39	0.0047	0.0038	0.0021	0.0019
44	40	-0.0023	0.0019	0.0019	0.0014	44	41	0.0016	-0.0007	0.0018	0.0010
44	42	-0.0000	-0.0001	0.0002	0.0007	44	43	0.0011	-0.0022	0.0014	0.0017
44	44	0.0039	0.0010	0.0023	0.0023	45	1	0.0064	-0.0048	0.0023	0.0023
45	2	-0.0023	-0.0025	0.0023	0.0023	45	3	-0.0023	-0.0044	0.0023	0.0023
45	4	0.0036	-0.0029	0.0023	0.0023	45	5	0.0030	-0.0001	0.0023	0.0023
45	6	-0.0024	-0.0025	0.0023	0.0023	45	7	-0.0008	0.0017	0.0023	0.0023
45	8	-0.0042	0.0019	0.0023	0.0023	45	9	0.0057	-0.0048	0.0023	0.0023
45	10	0.0025	-0.0003	0.0023	0.0023	45	11	-0.0007	-0.0002	0.0023	0.0023
45	12	-0.0052	0.0000	0.0023	0.0023	45	13	-0.0015	0.0000	0.0023	0.0023
45	14	0.0055	-0.0032	0.0023	0.0023	45	15	-0.0022	0.0032	0.0023	0.0023
45	16	0.0025	-0.0038	0.0023	0.0023	45	17	0.0036	0.0008	0.0023	0.0023
45	18	0.0011	-0.0040	0.0023	0.0023	45	19	-0.0031	-0.0030	0.0023	0.0023

NOTE: ALL VALUES TO BE MULTIPLIED BY 10**6

L	M	C(L,M)	S(L,M)	SIGMA C	SIGMA S	L	M	C(L,M)	S(L,M)	SIGMA C	SIGMA S
45	20	0.0046	0.0025	0.0023	0.0023	45	21	-0.0048	-0.0023	0.0023	0.0023
45	22	0.0025	0.0053	0.0023	0.0023	45	23	0.0022	0.0016	0.0023	0.0023
45	24	-0.0078	0.0074	0.0023	0.0023	45	25	0.0066	-0.0037	0.0023	0.0023
45	26	-0.0045	0.0037	0.0023	0.0023	45	27	-0.0049	0.0002	0.0023	0.0023
45	28	0.0070	-0.0001	0.0023	0.0023	45	29	-0.0090	-0.0042	0.0023	0.0023
45	30	0.0004	-0.0016	0.0023	0.0023	45	31	-0.0023	-0.0060	0.0023	0.0023
45	32	-0.0029	-0.0001	0.0023	0.0023	45	33	-0.0054	-0.0034	0.0023	0.0023
45	34	-0.0003	0.0031	0.0023	0.0023	45	35	-0.0046	0.0059	0.0023	0.0023
45	36	-0.0095	0.0076	0.0023	0.0023	45	37	-0.0047	0.0041	0.0023	0.0023
45	38	-0.0032	0.0055	0.0023	0.0023	45	39	-0.0039	-0.0086	0.0023	0.0023
45	40	0.0004	-0.0028	0.0010	0.0015	45	41	0.0004	-0.0024	0.0003	0.0009
45	42	-0.0001	-0.0121	0.0008	0.0023	45	43	0.0013	0.0024	0.0015	0.0021
45	44	0.0102	0.0004	0.0023	0.0023	45	45	-0.0007	0.0018	0.0023	0.0023
46	1	-0.0001	0.0017	0.0022	0.0022	46	2	0.0071	0.0028	0.0022	0.0022
46	3	-0.0010	0.0002	0.0022	0.0022	46	4	0.0017	-0.0055	0.0022	0.0022
46	5	-0.0047	-0.0064	0.0022	0.0022	46	6	-0.0049	-0.0015	0.0022	0.0022
46	7	0.0038	-0.0128	0.0022	0.0022	46	8	-0.0003	0.0037	0.0022	0.0022
46	9	0.0052	0.0014	0.0022	0.0022	46	10	0.0036	0.0005	0.0022	0.0022
46	11	-0.0018	-0.0026	0.0022	0.0022	46	12	-0.0007	0.0019	0.0022	0.0022
46	13	-0.0020	0.0003	0.0022	0.0022	46	14	0.0020	0.0001	0.0022	0.0022
46	15	-0.0028	-0.0005	0.0022	0.0022	46	16	-0.0012	0.0040	0.0022	0.0022
46	17	-0.0038	-0.0008	0.0022	0.0022	46	18	0.0014	-0.0045	0.0022	0.0022
46	19	-0.0003	-0.0036	0.0022	0.0022	46	20	-0.0018	-0.0040	0.0022	0.0022
46	21	-0.0056	0.0012	0.0022	0.0022	46	22	0.0058	0.0032	0.0022	0.0022
46	23	0.0002	0.0055	0.0022	0.0022	46	24	-0.0058	-0.0015	0.0022	0.0022
46	25	0.0026	-0.0071	0.0022	0.0022	46	26	0.0022	0.0075	0.0022	0.0022
46	27	-0.0001	-0.0018	0.0022	0.0022	46	28	0.0005	-0.0054	0.0022	0.0022
46	29	-0.0014	-0.0028	0.0022	0.0022	46	30	-0.0029	-0.0077	0.0022	0.0022
46	31	0.0014	-0.0008	0.0022	0.0022	46	32	-0.0016	-0.0025	0.0022	0.0022
46	33	0.0121	0.0024	0.0022	0.0022	46	34	-0.0043	0.0023	0.0022	0.0022
46	35	-0.0020	0.0001	0.0022	0.0022	46	36	-0.0002	-0.0022	0.0022	0.0022
46	37	-0.0054	0.0040	0.0022	0.0022	46	38	-0.0046	-0.0004	0.0022	0.0022
46	39	0.0057	0.0003	0.0022	0.0022	46	40	-0.0007	-0.0011	0.0022	0.0022
46	41	-0.0005	-0.0090	0.0020	0.0022	46	42	0.0003	0.0037	0.0008	0.0018
46	43	-0.0006	0.0082	0.0012	0.0021	46	44	0.0051	-0.0006	0.0022	0.0022
46	45	-0.0014	0.0061	0.0022	0.0022	46	46	0.0024	-0.0016	0.0022	0.0022
47	1	-0.0048	-0.0024	0.0022	0.0022	47	2	0.0050	0.0012	0.0022	0.0022
47	3	0.0007	0.0029	0.0022	0.0022	47	4	-0.0002	0.0034	0.0022	0.0022
47	5	-0.0014	-0.0029	0.0022	0.0022	47	6	0.0033	-0.0007	0.0022	0.0022
47	7	-0.0018	-0.0071	0.0022	0.0022	47	8	0.0046	0.0008	0.0022	0.0022
47	9	-0.0018	0.0041	0.0022	0.0022	47	10	0.0017	0.0020	0.0022	0.0022
47	11	-0.0004	-0.0026	0.0022	0.0022	47	12	0.0079	-0.0001	0.0022	0.0022
47	13	-0.0014	0.0011	0.0022	0.0022	47	14	-0.0026	-0.0015	0.0022	0.0022
47	15	-0.0006	-0.0006	0.0022	0.0022	47	16	-0.0009	-0.0032	0.0022	0.0022
47	17	-0.0012	0.0038	0.0022	0.0022	47	18	-0.0020	0.0079	0.0022	0.0022
47	19	0.0037	0.0022	0.0022	0.0022	47	20	-0.0103	0.0026	0.0022	0.0022
47	21	-0.0083	-0.0008	0.0022	0.0022	47	22	-0.0058	-0.0021	0.0022	0.0022
47	23	0.0047	0.0027	0.0022	0.0022	47	24	-0.0033	-0.0016	0.0022	0.0022
47	25	-0.0026	-0.0035	0.0022	0.0022	47	26	0.0084	0.0003	0.0022	0.0022
47	27	-0.0054	-0.0041	0.0022	0.0022	47	28	0.0046	-0.0059	0.0022	0.0022
47	29	0.0022	0.0005	0.0022	0.0022	47	30	-0.0030	0.0022	0.0022	0.0022
47	31	0.0014	0.0028	0.0022	0.0022	47	32	-0.0028	-0.0034	0.0022	0.0022
47	33	-0.0061	0.0041	0.0022	0.0022	47	34	-0.0009	0.0005	0.0022	0.0022
47	35	-0.0070	0.0018	0.0022	0.0022	47	36	0.0092	-0.0013	0.0022	0.0022
47	37	0.0064	0.0007	0.0022	0.0022	47	38	0.0008	-0.0006	0.0022	0.0022
47	39	-0.0025	0.0105	0.0022	0.0022	47	40	-0.0085	0.0079	0.0022	0.0022

NOTE: ALL VALUES TO BE MULTIPLIED BY 10**6

L	M	C(L,M)	S(L,M)	SIGMA C	SIGMA S	L	M	C(L,M)	S(L,M)	SIGMA C	SIGMA S
47	41	-0.0009	0.0055	0.0022	0.0022	47	42	-0.0026	-0.0040	0.0015	0.0018
47	43	0.0012	0.0001	0.0015	0.0005	47	44	-0.0035	0.0090	0.0022	0.0022
47	45	0.0110	0.0033	0.0022	0.0022	47	46	-0.0012	-0.0005	0.0022	0.0022
47	47	0.0035	-0.0046	0.0022	0.0022	48	1	0.0011	-0.0004	0.0021	0.0021
48	2	0.0063	0.0012	0.0021	0.0021	48	3	-0.0007	-0.0014	0.0021	0.0021
48	4	-0.0017	0.0003	0.0021	0.0021	48	5	0.0058	-0.0003	0.0021	0.0021
48	6	0.0042	0.0056	0.0021	0.0021	48	7	-0.0025	0.0001	0.0021	0.0021
48	8	0.0021	0.0021	0.0021	0.0021	48	9	-0.0039	0.0040	0.0021	0.0021
48	10	-0.0004	0.0037	0.0021	0.0021	48	11	0.0002	0.0018	0.0021	0.0021
48	12	0.0006	-0.0010	0.0021	0.0021	48	13	0.0026	0.0013	0.0021	0.0021
48	14	-0.0014	0.0018	0.0021	0.0021	48	15	0.0019	-0.0028	0.0021	0.0021
48	16	0.0001	0.0011	0.0021	0.0021	48	17	0.0026	0.0019	0.0021	0.0021
48	18	-0.0021	0.0028	0.0021	0.0021	48	19	-0.0015	0.0022	0.0021	0.0021
48	20	-0.0022	0.0042	0.0021	0.0021	48	21	-0.0012	-0.0027	0.0021	0.0021
48	22	-0.0062	0.0013	0.0021	0.0021	48	23	-0.0006	-0.0023	0.0021	0.0021
48	24	-0.0051	-0.0006	0.0021	0.0021	48	25	-0.0020	-0.0021	0.0021	0.0021
48	26	0.0000	-0.0061	0.0021	0.0021	48	27	-0.0063	0.0053	0.0021	0.0021
48	28	0.0044	-0.0065	0.0021	0.0021	48	29	-0.0004	-0.0048	0.0021	0.0021
48	30	-0.0021	-0.0014	0.0021	0.0021	48	31	-0.0019	-0.0021	0.0021	0.0021
48	32	0.0008	-0.0025	0.0021	0.0021	48	33	0.0018	-0.0021	0.0021	0.0021
48	34	0.0004	0.0049	0.0021	0.0021	48	35	-0.0036	-0.0020	0.0021	0.0021
48	36	-0.0014	0.0029	0.0021	0.0021	48	37	-0.0031	-0.0025	0.0021	0.0021
48	38	-0.0101	-0.0022	0.0021	0.0021	48	39	0.0043	-0.0090	0.0021	0.0021
48	40	-0.0001	0.0034	0.0021	0.0021	48	41	-0.0009	-0.0095	0.0021	0.0021
48	42	0.0028	0.0035	0.0021	0.0021	48	43	0.0001	0.0058	0.0007	0.0020
48	44	0.0023	-0.0001	0.0021	0.0021	48	45	0.0033	0.0067	0.0021	0.0021
48	46	-0.0015	0.0083	0.0021	0.0021	48	47	0.0060	0.0063	0.0021	0.0021
48	48	0.0051	-0.0008	0.0021	0.0021	49	1	0.0033	0.0001	0.0021	0.0021
49	2	0.0024	0.0032	0.0021	0.0021	49	3	-0.0027	0.0040	0.0021	0.0021
49	4	-0.0012	0.0092	0.0021	0.0021	49	5	0.0010	0.0004	0.0021	0.0021
49	6	0.0008	0.0020	0.0021	0.0021	49	7	-0.0003	0.0002	0.0021	0.0021
49	8	-0.0001	0.0023	0.0021	0.0021	49	9	-0.0002	0.0070	0.0021	0.0021
49	10	-0.0064	0.0006	0.0021	0.0021	49	11	0.0040	0.0007	0.0021	0.0021
49	12	-0.0040	-0.0013	0.0021	0.0021	49	13	0.0059	0.0044	0.0021	0.0021
49	14	-0.0001	-0.0001	0.0021	0.0021	49	15	0.0016	0.0008	0.0021	0.0021
49	16	-0.0012	-0.0070	0.0021	0.0021	49	17	-0.0014	-0.0018	0.0021	0.0021
49	18	-0.0016	-0.0066	0.0021	0.0021	49	19	-0.0011	-0.0021	0.0021	0.0021
49	20	0.0052	0.0006	0.0021	0.0021	49	21	-0.0012	-0.0058	0.0021	0.0021
49	22	-0.0014	0.0024	0.0021	0.0021	49	23	0.0050	-0.0007	0.0021	0.0021
49	24	0.0045	-0.0001	0.0021	0.0021	49	25	-0.0022	0.0024	0.0021	0.0021
49	26	-0.0073	-0.0007	0.0021	0.0021	49	27	-0.0027	0.0022	0.0021	0.0021
49	28	0.0018	-0.0107	0.0021	0.0021	49	29	-0.0020	0.0033	0.0021	0.0021
49	30	0.0041	0.0011	0.0021	0.0021	49	31	0.0000	-0.0047	0.0021	0.0021
49	32	-0.0020	-0.0051	0.0021	0.0021	49	33	0.0029	-0.0035	0.0021	0.0021
49	34	0.0042	0.0014	0.0021	0.0021	49	35	0.0051	0.0035	0.0021	0.0021
49	36	-0.0043	0.0039	0.0021	0.0021	49	37	-0.0020	0.0021	0.0021	0.0021
49	38	0.0039	-0.0016	0.0021	0.0021	49	39	0.0040	0.0023	0.0021	0.0021
49	40	-0.0020	0.0008	0.0021	0.0021	49	41	-0.0017	-0.0019	0.0021	0.0021
49	42	-0.0034	0.0069	0.0021	0.0021	49	43	0.0050	-0.0097	0.0021	0.0021
49	44	0.0063	0.0071	0.0021	0.0021	49	45	0.0020	-0.0002	0.0021	0.0021
49	46	0.0019	0.0041	0.0021	0.0021	49	47	-0.0004	0.0001	0.0021	0.0021
49	48	-0.0003	0.0017	0.0021	0.0021	49	49	0.0009	0.0040	0.0021	0.0021
50	1	0.0013	-0.0028	0.0020	0.0020	50	2	-0.0062	-0.0064	0.0020	0.0020
50	3	-0.0001	-0.0001	0.0020	0.0020	50	4	-0.0119	0.0026	0.0020	0.0020
50	5	-0.0017	0.0004	0.0020	0.0020	50	6	0.0004	0.0011	0.0020	0.0020
50	7	0.0031	0.0043	0.0020	0.0020	50	8	-0.0049	-0.0026	0.0020	0.0020

NOTE: ALL VALUES TO BE MULTIPLIED BY 10**6

L	M	$\bar{C}$(L,M)	$\bar{S}$(L,M)	SIGMA $\bar{C}$	SIGMA $\bar{S}$	L	M	$\bar{C}$(L,M)	$\bar{S}$(L,M)	SIGMA $\bar{C}$	SIGMA $\bar{S}$
50	9	-0.0023	0.0009	0.0020	0.0020	50	10	-0.0041	0.0008	0.0020	0.0020
50	11	-0.0030	0.0037	0.0020	0.0020	50	12	-0.0036	0.0040	0.0020	0.0020
50	13	0.0011	0.0019	0.0020	0.0020	50	14	-0.0027	0.0027	0.0020	0.0020
50	15	-0.0007	-0.0035	0.0020	0.0020	50	16	0.0005	-0.0067	0.0020	0.0020
50	17	0.0029	-0.0050	0.0020	0.0020	50	18	0.0031	-0.0051	0.0020	0.0020
50	19	0.0013	0.0018	0.0020	0.0020	50	20	0.0036	-0.0004	0.0020	0.0020
50	21	-0.0006	0.0003	0.0020	0.0020	50	22	0.0006	-0.0012	0.0020	0.0020
50	23	-0.0016	-0.0069	0.0020	0.0020	50	24	0.0101	-0.0000	0.0020	0.0020
50	25	0.0065	0.0039	0.0020	0.0020	50	26	-0.0058	0.0022	0.0020	0.0020
50	27	0.0006	-0.0012	0.0020	0.0020	50	28	-0.0012	0.0060	0.0020	0.0020
50	29	0.0035	0.0041	0.0020	0.0020	50	30	0.0038	0.0046	0.0020	0.0020
50	31	0.0010	0.0039	0.0020	0.0020	50	32	-0.0016	0.0014	0.0020	0.0020
50	33	-0.0024	-0.0038	0.0020	0.0020	50	34	0.0010	-0.0009	0.0020	0.0020
50	35	0.0021	0.0023	0.0020	0.0020	50	36	-0.0005	0.0012	0.0020	0.0020
50	37	-0.0055	0.0003	0.0020	0.0020	50	38	-0.0023	-0.0096	0.0020	0.0020
50	39	-0.0035	0.0079	0.0020	0.0020	50	40	0.0043	0.0055	0.0020	0.0020
50	41	-0.0048	-0.0043	0.0020	0.0020	50	42	0.0032	-0.0016	0.0020	0.0020
50	43	-0.0019	-0.0046	0.0020	0.0020	50	44	-0.0006	-0.0049	0.0020	0.0020
50	45	0.0006	0.0032	0.0020	0.0020	50	46	-0.0039	0.0061	0.0020	0.0020
50	47	-0.0055	-0.0098	0.0020	0.0020	50	48	-0.0022	0.0016	0.0020	0.0020
50	49	0.0031	-0.0059	0.0020	0.0020	50	50	0.0029	0.0032	0.0020	0.0020

NOTE: ALL VALUES TO BE MULTIPLIED BY 10**6

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-8